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Terrestrial Plant Ecology in Great Smoky Mountains National Park Biosphere Reserve: A Fifteen-Year Review and a Program for Future Research

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TERRESTRIAL PLANT ECOLOGY IN GREAT SMOKY MOUNTAINS NATIONAL PARK BIOSPHERE RESERVE: A FIFTEEN-YEAR REVIEW AND A PROGRAM FOR FUTURE RESEARCH

by Peter S. White[1]

NATIONAL PARK SERVICE - Southeast Region

Research/Resources Management Report SER-84

National Park Service
Cooperative Park Studies Unit
Department of Forestry, Wildlife and Fisheries
University of Tennessee
Knoxville, Tennessee 37901-1071

[1] Present address: Department of Biology, University of North Carolina, Chapel Hill, North Carolina 27514

April 1987

UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

Richard H. Dawson

ABSTRACT

Eleven years have elapsed since the establishment of the science program in Great Smoky Mountains National Park in 1975. Because of growth in the research program, the turnover of staff, and shifts in research funding, the tracking of individual research projects and data sets has become an important issue in research management. The goals of this report are to: (1) present a history of plant ecology research in the park for the years 1975-1985 and (2) present an overview of the findings, goals, and organization of the plant ecology program. Based on a review of National Park Service legislation and policies, 15 general research-related management objectives are listed and are used to organize this overview. Three research themes are developed to focus the broad catalogue projects in the plant ecology prospectus: vegetation dynamics, landscape pattern, and the protection of biological diversity. Understanding and mitigating human influence will require understanding at these three levels of inquiry. Top priority projects include remote sensing of vegetation pattern, establishment and annual inventory of permanent reference plots, the documentation of wild hog impacts, cause and effect research in air quality impacts, understanding of fire behavior, and conservation of the Fraser fir gene pool.

Citation:

White, Peter S. 1987. Terrestrial plant ecology in Great Smoky Mountains National Park Biosphere Reserve: A fifteen-year review and a program for future research. U.S. Department of the Interior, National Park Service, Research/Resources Management Report SER-84. Southeast Regional Office, Atlanta, Georgia 30303. 70 pp. plus appendices.

ACKNOWLEDGEMENTS

I gratefully acknowledge the patience and help of Jim Wood, Editor, Science Publications, of the Southeast Regional Office of the National Park Service, in editing this manuscript. I would also like to thank S. P. Bratton and M. E. Harmon for their thoughtful reviews of this manuscript, particularly with regard to past research and future directions. I would like to thank J. R. Stottlemyer for his important comments on my treatment of the National Park Service research mandate and J. Peine for his comments on my outline of future research directions.

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INTRODUCTION

When the science program was established in Great Smoky Mountains National Park (GRSM) in 1975, it brought about better cooperation with the outside research community, better problem definitions for park research, and the acquisition of grants from the National Park Service (NPS) and outside sources. Research results in plant ecology have been directly used by park managers in air quality protection, grassy balds restoration, visitor impact management, rare plant protection, and European wild hog management. Our experience in Great Smoky Mountains National Park parallels the general trend noted by Mack et al. (1983)--that national park biosphere reserves with in-house research programs tend to have more strongly developed assessments of resource threats and a better overall research strategy, compared to sites that depend solely on outside sources for research support.

One of the most neglected tasks in research organizations is that of periodic synthesis and historical overview; generating primary research publications has generally taken precedence over such tasks. In GRSM, the sheer growth in the number of projects, the turnover of research staff, and the ebb and flow of funds for particular efforts has made the tracking of projects and data sets an important quality control issue. Three recent projects in the GRSM Science Divison have been designed to meet this challenge: Peine et al. (1985) summarized the park's extant data bases, MacKenzie (in review) has presented the Science Division's data management strategy, and White et al. (1985) created a register of air quality-related projects. These efforts seek to establish long-term continuity in the park's research programs, a key goal of the Man and the Biosphere (MAB) Program (Franklin 1985).

The objectives of this report are to (1) present an overview of recent vegetation research in GRSM and (2) offer a general outline for development of future studies. My intention in the first of these tasks is not to present a detailed review of the results of previous research, but rather to address the more specific question, "How adequate is the information base relative to National Park Service management objectives?" Hence, I will first discuss what these objectives are. This report is the first review of GRSM's plant ecology program since the publication of "Ecological problem definition in Great Smoky Mountains National Park" by S. P. Bratton (1976a; this report was the first publication in the Southeast Region's Research/Resources Management Report Series). In discussing the history of this research, I will also present a data base listing over 300 projects that have been carried out by NPS and outside researchers during the last 15 years (Appendix I) and a bibliography of over 500 items on plant ecology and related subjects in the park (Appendix II). The structure of the project register data base is also presented in Appendix I; this structure may have general use as a tracking system for research projects.

The discipline of plant ecology is important in GRSM for the following reasons:

1. GRSM is the largest preserve of temperate diversity in eastern North America. The park is internationally known for the diversity of its flora, the complexity of its vegetation patterns, and the survival of remnant old-growth forests.

2. The fastest growing research area in GRSM is currently related to air quality, with much of this research in plant ecology (e.g., physiological impacts on sensitive species, changes in plant communities and populations).

3. Further, understanding vegetation structure and dynamics is central in ecosystem-level studies. The primary productivity, standing crop biomass, and organic matter pools of forest floor and soils are essential features of ecosystems. Ecosystem processes related to vegetation structure and dynamics influence the physical and chemical characteristics of GRSM's stream ecosystems (Silsbee and Larson 1983).

4. Finally, the human values associated with the National Park are very much related to its vegetation: the spring flora, fall color, remote wilderness landscape, record tree sizes, and old-growth stands directly support aesthetic values and are, in part, responsible for the park's high annual visitation.

This report is organized into five sections:

1. An overview of other efforts in bibliography and synthesis for GRSM research;

2. A discussion of research-related management objectives for Great Smoky Mountains National Park based on a review of National Park Service legislation and policy, and the park's Resources Management Plan (1984);

3. An administrative history of research in GRSM, with particular reference to the development of research in plant ecology (in this section I will review the priorities developed by Bratton in 1976);

4. An overview of plant ecology related projects conducted during the last 15 years in GRSM; and

5. Goals and priorities for future plant ecology research.

Two Appendices provide specific details that support the text sections: Appendix I presents a register of plant ecology research projects by subject area, and Appendix II presents an indexed bibliography of GRSM research publications on vegetation, disturbance, and management.

OVERVIEW OF OTHER BIBLIOGRAPHIES AND SYNTHESES

Three efforts have been made to construct bibliographies of research and management in GRSM. The first of these (1978-present) is an ongoing series of bibliographies on the human and natural history of the southern Appalachians (Appendix II, Part C). The goal of this series, developed in 1978 by Uplands Field Research Laboratory in concert with the park's Interpretation and Resource Managment Divisions, was to compile and index relevant research for the park and the southern Appalachian region as a whole. Research that has been conducted outside GRSM is often relevant to the understanding of ecosystems and management problems in the park and thus helps the park prioritize research needs. Further, knowing what projects have been completed elsewhere allows better formulation of park research projects and will potentially allow the park to better interact with the outside research community. The organizers of this project also recognized the importance of Great Smoky Mountains National Park as a Biosphere Reserve within the larger, regional, biogeographic province of the southern Appalachians. Thus, a regional approach to the scientific literature was adopted. Bibliographies that have been prepared to date are listed in Appendix II, Part C.

The southern Appalachian bibliography series has included an index to studies by subject category. In the early bibliographies the indexes were computerized using a card-image, 80-column format. Each reference was given a code number in these computer indexes (the reference itself was not computerized). This has subsequently been abandoned because of the lack of resources to perform regular updates and searches of the data base and because the widespread availability of micro-computers has replaced the need to use the University of Tennessee mainframe computer. We are now testing a bibliographic data base developed by Mark MacKenzie for this purpose and all references from Appendix II have been entered on that system. We are also working with researchers at Oak Ridge National Laboratory (ORNL) on a GRSM data base, including a keyworded bibliography of ecological research (V. Dale, R. Gardner, and P. White, in preparation; Appendix I has also been used in this effort).

The second bibliographic effort was the MAB-sponsored review of science in Great Smoky Mountains National Park Biosphere Reserve (McCrone et al. 1982). This effort was confined to research carried out within the park itself. The research was categorized by subject area and the principal methods and findings of the studies were reviewed and summarized. A programmatic approach to plant ecology was not taken, however. This report also differs from McCrone et al. (1982) in that it will present an overview of research by project title rather than by individual research publication.

The third bibliographic effort was an overview of threats to Great Smoky Mountains National Park (Carpenter 1982). This project was sponsored by the Great Smoky Mountains Natural History Association. While it is an important compilation of threats to the park, no specific research program was described.

In addition to these three efforts, several other efforts at synthesis have been carried out for specific subject areas. These include four workshops held by GRSM: on the southern Appalachian spruce-fir ecosystem

(White 1984), the control of the European wild hog (Tate 1984), the management of biosphere reserves (Peine 1985), and the usefulness of geographic information systems (J. Carter, in preparation). Three regional SARRMC (Southern Appalachian Research/Resource Management Cooperative) workshops have also been held: on the balsam woolly adelgid (Hay 1980), the European wild hog (Hair et al. 1980), and grassy balds management (Saunders 1980). Discussions of the park's research needs are contained in Bratton (1976a, 1976b), Tate (1984), White (1984), and Peine et al. (1985). I will draw on these discussions in the final section of this report. Finally, some of the material presented (e.g., the research chronology, Table 9) was adapted and expanded from material originally assembled for the 1982 Southeast Region administrative review of the science program in GRSM.

RESEARCH OBJECTIVES FOR THE NATIONAL PARK SERVICE AND GREAT SMOKY MOUNTAINS NATIONAL PARK

My purpose in this section is to develop a list of research objectives for GRSM based on a review of National Park Service and Biosphere Reserve Program policies. I will show that much of the research mandate is contained in broad policy statements, but a few specific mandates have also been established. The most important of the specific research mandates is that of air quality effects research, while the most important research mandate from an international perspective is contained in the goals of the Biosphere Reserve Program. I will also show that interpretation of the National Park Service research mandate has evolved since the agency was established 70 years ago--from an early emphasis on resource inventory and the mitigation of the effects of direct human intrusion to an emphasis on specific resource threats and the emerging role of national parks in a regional and international conservation strategy. I will purposefully phrase research objectives in the context of management objectives; the tie between research and management is a critical one and the ambiguity of the research mandate reflects the varying interpretations of the management goals of national parks.

The development of this perspective is important because basic NPS legislation contains broad policy mandates, rather than explicit reference to research (Dennis 1985). Generally speaking, the NPS policy mandates have not been used to define a specific role for research; this has resulted in a number of recent attempts to define NPS management philosophy and the role of science in national parks (Bonnicksen and Stone 1982, Bratton 1985, Dennis 1985, Graber 1983, Sumner 1983, White and Bratton 1980). Here, I will explore the question, "What are the general concepts that can be used to structure a National Park Service research program and how do these apply to plant ecology research in GRSM?" The answer to this question is tied to the management objectives of the National Park Service. Hence, I will trace the development of research objectives from the broad statements of early National Park Service legislation to the more specific statements contained in the management objectives for Great Smoky Mountains National Park.

In the following paragraphs I will discuss: (1) general NPS statements of purpose; (2) specific legislative mandates for NPS research; (3) the Biosphere Reserve and World Heritage Programs; and (4) the GRSM Statement for Management, General Management Plan, and Resources Management Plan (this section will allow me to illustrate general NPS management objectives with specific resource issues in GRSM).

General Statements of NPS Purpose and the Issue of Resource Stability

General NPS legislation. The general protection of natural resources is specified in the National Park Service Organic Act of 1916, in the Act of 1925 that authorized planning for the development of a national park in the southern Appalachians, in the Act of 1926 that authorized the development of Great Smoky Mountains National Park, and in the Act of 1942 that further defined park protection (Table 1). All four of these acts use similar language to describe the purpose of national parks. In the Organic Act, this purpose is:

> "to conserve the scenery and the natural and historic objects, and the wildlife therein, and to provide for the enjoyment of the same... by such means as will leave them unimpaired for...future generations".

In the Act of 1926 the purpose of Great Smoky Mountains National Park is:

> "to preserve the exceptionally diverse resources and to provide for public benefit from and enjoyment of those resources in ways which will leave them...unimpaired by modern human influence."

In the Act of 1942 the mission of GRSM is to provide for:

> "preservation from injury or spoilation of all timber, mineral deposits, natural curiosities or wonderful objects, and for the protection of animals and birds in the park from capture or destruction,..."

The general purpose of the National Park Service is reaffirmed in the Wilderness Act of 1964 (which establishes the highest standards for protection from human influence in wilderness areas; wilderness has been proposed for GRSM but has not yet been officially designated), the Concessions Policy Act of 1965 (which permits concessions only in areas where they cause the least impact to core park values), and the National Environmental Policy Act of 1969 (which mandates environmental review of management and development plans). Among these acts, the Wilderness Act alone carries a specific reference to research (e.g., the establishment of pristine wilderness reference areas is one of the reasons for designation of wilderness areas).

The early legislative statements of NPS purpose are generalized. They support two general categories of research. First, the goal of preserving resources in perpetuity implies the need to know the nature and trajectory of the resources that are present; this evaluation is required if management success is to be evaluated. The second research objective derives from the fact that the parks are clearly established not only to protect natural resources but to provide for their enjoyment in a manner that does not constitute an intrusion of modern man and does not cause lasting impacts. Thus, the dual mission of the National Park Service implies a need to monitor visitor impacts to natural resources. The early legislation strongly implies that recreational and aesthetic values are related to ecosystem and landscape integrity. For example, in Great Smoky Mountains National Park these human values can be identified with vistas of the large, man-free, wilderness landscape; the abundance and diversity of flowering plants; and the presence of virgin forests with trees that

Table 1. Legal and policy mandates for research in National Parks with special reference to Great Smoky Mountains National Park.

Descriptive Title	Date	Purpose and research mandate
NPS Organic Act	1916	Establishes purpose of National Parks and other units
Act of 1925	1925	Provides for securing lands in the southern Appalachian region
Act of 1926	1926	Authorizes planning for development of Great Smoky Mountains National Park
Act of 1934	1934	Provides for final establishment of Great Smoky Mountains National Park
Act of 1942	1942	Further provides for protection of timber, mineral deposits, and wildlife in GRSM
Wilderness Act	1964	Reaffirms highest standards of protection for human-free wilderness areas
Concessions Policy Act	1965	Permits concessions only where they cause the least impact to core park resources
National Trail Systems Act	1968	Provides for coordination of management of the Appalachian Trail
National Environmental Policy Act	1969	Mandates assessment of environmental influences of Federal management policies
Convention Concerning the Protection of the World Cultural and Natural Heritage	1973	Describes establishment of World Heritage Sites
Endangered Species Act	1973	Mandates inventory of endangered species, biological assessments of management policies, and consultation with US Fish and Wildlife Service on compliance
Biosphere Reserve Designation	1976	Established Biosphere Reserve Program in GRSM
Convention on the International Trade in Endangered Species (CITIES)	1977	Regulates trade for protected plants
Clean Air Act	1977	Mandates the protection and enhancement of air quality in Class I Airsheds; protects Air Quality Related Values (AQRVs) including visibility and natural resources; mandates at AQRV and visibility management plan, research and monitoring related to air quality, and coordination with states in State Implementation Plans (SIPs).
President's Executive Order 11987	1977	Restricts the introduction of exotic species into natural ecosystems; mandates encouragement of state and local governments and private citizens to avoid exotic species introductions
NPS Policy on Exotics	1978	Establishes Service wide policy on exotics
North Carolina rare plant legislation	1979	Protects state listed plants
Natural Heritage Act Ammendment	1980	Authority for World Heritage Site designations
Lacey Act	1981	Protects fish, wildlife, and rare plants from illegal harvest
Tennessee rare plant legislation	1985	Protects state listed plants

surpass 300-500 years in age and 2.5 m in diameter. Legislation specific to GRSM also employs generalized language, but specifically describes the park's scenery and diversity as key resources.

Early statements of purpose and the question of resource stability. The omission of an explicit research mandate in early NPS legislation derives, at least in part, from the assumption that establishing national parks, and policing human activities within park boundaries, would assure success of the preservation mission. This concept is, in turn, based on the assumption that large natural areas are stable or are recovering toward stability from past human influence. (The early western national parks were pristine when first established, although the issue of Native American effects was not fully understood; on the other hand, early eastern parks, including GRSM, had been influenced in part by logging and other direct human impacts.) This assumption reflects both a social view and the lack of understanding within the scientific community. Since the establishment of the National Park System, however, resource change in protected areas, whether from natural or human causes, has become a universal conservation issue (White and Bratton 1980). Some changes permeate park boundaries in ways not envisioned by early planners (e.g., air pollution and exotic species invasions), while other changes result from the interaction of park management decisions with natural processes (e.g., fire supression results in failed reproduction in disturbance dependent trees). The realization that natural disturbances are intrinsic to ecosystems has implications for National Park Service management (that is, preserved natural areas are not static). This is exemplified in the coastal areas, where shorelines and dunes are shaped by natural dynamics of coastal processes (Dolan et al. 1978) and in fire-dependent ecosystems, such as prairies and some coniferous forests, where fire suppression has resulted in resource change (Heinselman 1973).

The early NPS legislation reflects the views of nature and the state of ecological science in the early 1900s. At the time of the National Park Service Organic Act and the creation of Great Smoky Mountains National Park, ecological science was dominated by views that old-growth ecosystems and wilderness landscapes were self-regulated and relatively stable if human influence was excluded. This view has been replaced with a fuller understanding of the importance of natural disturbances and the influence of secular environmental change (Pickett and White 1985). Ecosystems, even if the influence of man is removed, are not static museum objects. Further, human-caused threats to natural ecosystems occur from both outside and within park boundaries. Thus, a research challenge is posed in the National Park Service mission: there is an implied need to understand ecosystem state and trajectory and the interplay of human and natural causes of change. The need for research in these areas can be seen in early discussions of National Park Service management issues (see discussion of Adams (1925) in Stottlemyer (1984)) and in the pioneering NPS research program developed under George Wright in the 1930s (see Sumner 1983).

The question of stability in natural systems is also tied to spatial scale. Ecosystem change on a local scale may provide for equilibrium on a broader-scale. For example, fire causes dramatic local change, but from a larger perspective there may be a relatively stable distribution of land in various disturbance history states (further, native species may depend on

this landscape mosaic; this is the "shifting mosaic" of Heinselman (1973)). Such dynamic equilibria are to be expected only when patch size is small relative to landscape scale, when there is positive feedback between community state and disturbance vulnerability (i.e., when disturbance vulnerability increases with time since disturbance), and if the climate is relatively stable (White and Pickett 1985). These conditions may hold for some ecosystem types and some species in a particular park, but not for others.

In research that was particularly applicable to the National Park Service, Romme and Knight (1982) showed that a 7300 ha watershed in Yellowstone National Park was too small to be in equilibrium with the fire regime and predicted that the entire park was just large enough to be described by equilibrium dynamics. Within their study watershed, they predicted that wildlife populations, water quality, and fish populations would fluctuate on cycles of several hundred years, even within large watersheds, because of the non-equilibrium patch structure of the Yellowstone landscape. This observation has two interesting corollaries. First, the study of external threats, such as air pollution, will often be carried out in systems that are patchy, with each patch following a dynamic trajectory that may interact with the influence of the external threat. Second, there will sometimes be conflicts between National Park Service goals: within the Romme and Knight study watershed, a natural process (fire) was hypothesized to have caused local fluctuation in native wildlife populations.

The question of park size and resource stability is especially important in the protection of large and/or migratory animals. For example, large mammals may have large home ranges, occur at low population densities, require large areas for protection of minimum viable population sizes, and migrate seasonally beyond park boundaries. If parks were universally large enough to contain equilibrium dynamics of ecosystems and to contain seasonal habitat for the species they protect, National Park Service research could conceivably be devoted entirely to the issue of direct human threats. However, even the largest national parks, such as Yellowstone, do not contain the entire home range necessary for some large mammals (Leopold et al. 1963, Stone 1965).

From these arguments, then, we can conclude that external threats to park resources will often interact with non-equilibrium park systems (Bonnicksen and Stone 1982); that, even in the absence of external threats, basic ecosystem research and active management will usually be required to meet NPS goals; that external threats and varying climates further support the idea that park resources will not often be influenced solely by internal processes; and that the conservation of at least some protected resources will require both regional and international action (e.g., migratory birds).

The general recognition of the importance of research in the national parks dates from the publication of two reports in 1963 (Leopold et al. 1963, Robbins et al. 1963). Both reports addressed resource stability, natural disturbance, and external threats. The Leopold Report was developed to address the then-controversial aspects of wildlife management in national parks (e.g., the reduction of large populations of native mammals in Yellowstone National Park to prevent overgrazing). The Leopold

Report also went beyond the particular issues of its time to point out the need for a broader base of research studies in national parks. This report made observations that are similar to those discussed above: that is, in order to effectively manage national parks, an information base on the natural dynamics and processes of ecosystems is required. The Robbins Report outlined the importance of research in national park management and recommended steps for expanding the research program. These two reports led directly to the increased emphasis on science and resource management in national parks during the last twenty years.

The Leopold Report described the one broad purpose of national parks as the protection of "vignettes of primitive America" as they existed in the pre-Columbian era (Leopold himself later came to regard this phrase as inappropriate, Stottlemyer, personal communication). This simple characterization has led to two controversies. First, it suggests a management reference state. This has proved controversial since ecosystems are dynamic (the pre-Columbian landscape was not static and the recreation of a historic ecosystem state is arbitrary) and historic data are, in any case, usually insufficient for use to construct quantitative management goals. Second, the pre-Columbian era was characterized by substantial Native American influence, especially in terms of fire and wildlife populations; the question then remains whether to mimic these influences or to allow natural successional processes to occur.

Specific Legislative Mandates for Research

While the general goal of resource protection is clear in the basic acts relating to the National Park Service, the two most specific mandates for Park research programs are the Clean Air Act (1977) and the Endangered Species Act (1973) (Table 1). With regard to research on the environmental impacts of alternatives for park management and development, the National Environmental Policy Act (NEPA, 1969) is a third legal mandate for specific kinds of research. The specificity of these three laws reflects the shift in societal attitudes concerning environmental issues: starting in the mid-1960s, there was a recognition that specific threats to man's environment existed, requiring the evaluation of particular threats and the special protection of particularly vulnerable resources. This was later reflected in the emphasis on the documentation of threats to the national parks (USDI, National Park Service, 1980).

The Clean Air Act (as amended 1977) is an important tool for protection of park resources (Ross 1985). This act mandates research and monitoring on air quality in Class I airsheds. Land managers for these areas are directed to preserve, protect, and enhance the air quality of their areas. Section 165 is particularly relevant to protection of natural resources in that it requires affirmative action to protect Air Quality Related Values (AQRVs; these include natural resources affected by pollution and visibility). Managers are further required to work with the states in the development and approval of State Implementation Plans (SIPs). In GRSM, air quality is a top priority issue for research because the park is a Class I airshed, because the park receives high levels of sulfate deposition, nitrate deposition, and ozone exposure, because the park's ecosystems are vulnerable to air quality effects, and because the Clean Air Act has created a specific legal mandate for management action.

The Endangered Species Act (1973) mandates inventory of Federal lands for the presence of endangered species followed by monitoring of these species and the development of plans to ensure their survival. Biological assessments are to be performed to determine whether management alternatives and development plans will affect these species. Federal land managers are to consult with the U.S. Fish and Wildlife Service over compliance with the provisions of this act. Also related to the Endangered Species Act are the Lacey Act (as amended, 1981) and the Convention on International Trade in Endangered Species (CITIES, 1977). The former deals with penalties for illegal harvest of wildlife and rare plants; the latter deals with regulation of export and import of endangered species. In addition, the states of North Carolina and Tennessee have both enacted specific legislation on rare plant protection. These laws require the assessment of potential impacts to listed species. Protection of rare species, along with species impacted by acute threats, is tied directly to protection of genetic diversity.

Like the biological assessment provisions of the Endangered Species Act, the National Environmental Policy Act (1969) serves to require specific environmental assessments (which may lead to full-scale environmental impact statements) of management and development alternatives for Federal land management. Both acts thus serve to add specific management requirements for research data to the basic National Park Service protection mandate.

There are several kinds of park threats such as the influence of development around parks and the intrusion of noise (e.g., the recent controversy over aircraft in Grand Canyon National Park) that are not covered by specific legislation at this time (however, early and very broad NPS legislation can be used to challenge these threats). A question emerges from this: Is such specific legislation needed to ensure the fulfillment of the early intentions of the establishment of the National Park System?

The Biosphere Reserve and World Heritage Programs

Great Smoky Mountains National Park was designated as an International Biosphere Reserve in 1976 and as a World Heritage Site in 1983. Both programs were designed to bring international visibility to the need for preserving natural and cultural resources (Roland Wauer, unpublished manuscript). Both programs highlight the importance of preserving biological and genetic diversity. The World Heritage Site designation derives from United States ratification of the Convention Concerning the Protection of the World Cultural and Natural Heritage (1973) and the Natural Heritage Protection Act Amendment (1980). The program is oriented around public education and conservation action to assure protection of threatened sites.

The MAB Program of the United Nation's Educational, Scientific, and Cultural Organization (UNESCO) carries a specific research mandate. The goals of this program are to provide an international network of areas representative of the world's biogeographic provinces for ecological and environmental research, including long-term and baseline studies. There are four major areas of concern for MAB research programs (Table 2, adapted from Franklin 1985): research management (e.g., a strong research

Table 2. Program elements for Biosphere Reserve research (adpated from Peine 1985, Franklin 1985).

RESEARCH MANAGEMENT
Develop an information system
Compile comprehensive research history
Develop a strong research archive and reference collections
Develop a data management strategy
Provide field and logistical support for research
RESEARCH STRATEGY
Perform holistic studies
Initiate a long-term monitoring and research program
Encourage interdisciplinary studies
Complete resource inventories and design baseline studies
NETWORKS AND COMPARATIVE STUDIES
Coordinate research in core and experimental areas
Perform comparative studies on a regional, national, and international scale
Participate in monitoring networks
RESEARCH AREAS FOR EMPHASIS
Study protection of genetic resources
Study conservation strategy and preserve design
Study theoretical and practical aspects of wise resource use

presence, adequate facilities, and quality-assured data management), research strategy (e.g., long-term, interdisciplinary, and holistic studies), networking and comparative studies (e.g., regional and international projects, participation in environmental monitoring networks), and specific research areas in conservation of resources (e.g., protection of genetic diversity, conservation strategy, and sustained use of natural resources).

The MAB research mandate is distinctive in that it enlarges the sphere of interest from the boundaries of a particular national park to the regional and international scale. There are several reasons for this increase in scope. First, the resources contained within biosphere reserve parks are international in significance. Threats to those resources are at least regional and usually international in scope. Second, protected resources (e.g., large mammal populations and migrating bird species) and resource threats (e.g., air pollution) transverse park boundaries, leading to the direct importance of the relationship of protected areas to their surroundings. Apart from these reasons (which could conceivably be considered to be included within the general NPS mandate), the Biosphere Reserve Program emphasizes the importance of an integrated regional approach to conservation. Ideally, Core Conservation areas (including biosphere reserve parks) function to protect genetic diversity and to serve as sites for baseline studies and monitoring within a larger biogeographic province. The Biosphere Reserve Program seeks to integrate strict preservation with other conservation objectives, such as the sustained use of natural resources outside core conservation areas.

Although the objective of preserving genetic diversity might be said to be contained in the general National Park Service policies dealing with the protection of species and ecological processes, the Biosphere Reserve and World Heritage emphasis on this conservation objective is a distinctive contribution of these international programs to National Park Service research and management objectives.

The Biosphere Reserve and World Heritage Programs exemplify a continuing evolution in conservation strategy. This strategy emphasizes the building of an international system of protected areas--large national parks have been used in this network as core conservation areas representative of the undisturbed conditions of regional biogeographic provinces. The regional and international emphasis of these programs contrasts with the early National Park Service statements of purpose for which the park boundary defined the area of interest. As discussed above, the early statements of purpose supported only analysis of internal park change and visitor impacts. The Biosphere Reserve and World Heritage concepts represent an enlargement of scope to regional and international issues.

Research Objectives in GRSM Policy Documents

Statement for Management. The broad objectives described above were used to formulate the specific goals for Great Smoky Mountains National Park, as described in the Statement for Management (approved in 1978).

This statement was used, in turn, in the formulation of the General Management Plan (approved 1983). With regard to natural resources, the goals listed in the Statement for Management are:

> To manage the park in a manner consistent with the purposes of preservation, enjoyment, and benefits to humankind through scientific study of its distinctive combination of natural and cultural resources;
>
> To protect and perpetuate the significant and diverse natural resources and ecosystems found at Great Smoky Mountains National Park, keeping them as free as possible from the adverse influences of human intrusion...;
>
> To protect and, where possible, to restore the natural processes as they would proceed if they had never been influenced by non-Indian society;
>
> To ensure adequate protection for threatened and endangered species, critical habitat, and unusual or particularly vulnerable natural resources of the park, such as virgin forest, brook trout habitat, beech gaps, and outstanding cove hardwood stands;
>
> To minimize to the extent possible the adverse impact of exotic plants and animals on the park's natural resources and processes;
>
> To manage the park as a core unit of the Great Smoky Mountains International Biosphere Reserve, in accordance with the objectives of the Man and the Biosphere Program.

This statement echoes in part the general sentiments of early NPS legislation, but it also more strongly asserts the need for research to support park management. The section on acquisition of information states that the National Park Service should "encourage and participate in efforts to acquire information...in order to facilitate development of the best possible strategies for perpetuating and preserving the significant natural...resources" and should identify and monitor: "major geological, hydrological, biological and other natural features", "...the influence of such external factors as air pollution and radiation on park resources...", "the influence of visitor use and activities, and of the facilities and services provided in support of them...", and "the influence of exotic plants and animals on the park's natural and cultural resources and processes." The park should also monitor "threatened and endangered species, critical habitats, and other particularly vulnerable resources of the park...".

The contrast between the early NPS legislation and the Statement for Management shows the change in attitudes on the part of some NPS managers between the early 1900s and 1970s. In the earlier period the purpose of parks was expressed as protection from direct resource extraction and visitor impacts. By 1978 the survival of park resources was seen as threatened by specific agents: air pollution, exotic species, and changes in natural processes (fire suppression). Unique ecosystems and resources and rare species are seen as requiring special protection. The National Park Service manual of Management Policies (USDI, National Park Service

1978) dates from this same time period and recognizes similar categories of threats and special categories of protection (especially for rare species: "Plant and animal species considered to be rare or unique to a park shall be identified...and their distribution within the park mapped").

With regard to changing conservation objectives, an interesting contrast can also be seen in the treatment of ecosystem restoration in GRSM and in Redwoods National Park. Both parks possess lands that had received substantial logging impacts before land acquisition. Ecosystem restoration has been a key issue in the more recently established Redwoods National Park, while it has been generally ignored in GRSM, despite the continuing lack of recovery on some areas affected by pre-park disturbance. Likewise, while chestnut blight was seen as a severe resource threat in the early years of GRSM, it was not as formally addressed in statements of park purpose as was the current outbreak of balsam woolly adelgid. Finally, the evolution of attitudes can be seen in park objectives with regard to grassy balds. In the early years of GRSM management, the issue of grassy balds management was predicated on the assumption that they were natural communities. By 1978 it had been determined that grassy balds were neither natural nor stable; subsequent restoration of two balds has been based on the importance of grassy balds in the maintenance of landscape and biological diversity, rather than on the finding that human-caused threats were impacting a natural resource (White 1983). Two grassy balds were preserved as examples of a regionally important plant community.

The General Management Plan. GRSM's General Management Plan (1983) reaffirms the basic purpose of the park as discussed above. The only reference to a specific research project in plant ecology is the statement that "research into the natural role of fire will be conducted and measures instituted to restore park ecosystems as fully as possible to natural conditions" (prescribed fire is also mentioned in conjunction with the red-cockaded woodpecker habitat). Other references to the research program include general areas such as measures to reduce hog impact ("especially in areas of special scientific value, fragility or aesthetic appeal"), the designation of Andrews and Gregory Balds as Research Experimental Areas (to permit manipulation in grassy balds restoration), monitoring of visitor impacts (e.g., on Mt. LeConte), and the building of a research facility at Twin Creeks. The General Management Plan zones the park into areas subject to different management policies. The discussion here concerns predominantly the natural area zone (proposed wilderness).

The Environmental Impact Statement for the General Management Plan gives further detail on the park research programs referred to above. Additional research topics mentioned are: air quality impacts (including those along heavily travelled roads, where the effects are said to be unknown), development of a floodplain information base, research on southern pine beetle, control of balsam woolly adelgid, effects of chestnut blight, control of exotic plants, protection of endangered species, and the need for biological and environmental assessments of all park development plans.

The Resources Management Plan. The GRSM Resources Management Plan, based on the Statement for Management and the General Management Plan, is the official summary of resource management issues in the park and is the central planning document for park research and resources management

programs. The current (1984) plan lists 26 project statements (Table 3), of which 11 contain plant ecology research topics. These 11 plant ecology project statements contain 36 individual research and monitoring titles, 17 of which are either ongoing funded studies or recently completed projects (Table 4).

The 36 plant ecology research and monitoring titles fall into eight broad management objectives (Table 4): understand air quality effects (7 titles), assess and control exotic species (10 titles), restore natural processes (5 titles), perform baseline studies and long-term monitoring (6 titles), maintain special protection areas (3 titles), monitor visitor impacts (1 title), protect rare species (1 title) and protect gene pools (1 title). Of the remaining titles, one project concerns hazardous trees and one concerns roadside and landscape management in developed areas. The 36 Resources Management Plan titles address 12 park-specific resource management issues. Among these issues are six specific threats to park resources (air quality effects, balsam woolly adelgid infestation, exotic plant impacts, grassy balds succession, European wild hog impacts, and visitor impacts), two issues related to natural ecological processes in pine stands (fire regime changes and southern pine beetle effects), and four issues related to baseline data requirements (special protection area inventory, resource basic inventory, rare plant distributions, and ecosystem analysis). These 12 categories are among those used in the project register in Appendix I.

In 1985 the Superintendent issued a list of proposed projects to implement the Biosphere Reserve Program in the park. These projects include research on genetic diversity (rescue of the American chestnut gene pool), two projects on long-term ecosystem research (development of a cooperative watershed-based ecological study with Coweeta Hydrologic Laboratory and the holding of a workshop on permanent vegetation plot methods), an international project based on a biological diversity information system developed in the park, and a project to promote the management of roadsides and powerline rights of way with native plants. We are currently investigating ways of developing these projects. They have not yet been described in the Resources Management Plan.

Summary of the NPS and GRSM research mandate

Based on the discussion presented above, I have constructed a list of 15 general, research-related management objectives that extend the basic NPS mission of preserving "the scenery and natural...objects" and "exceptionally diverse resources" to a fuller statement that can be used to discuss GRSM research needs (Table 5). I have purposefully stated these as management objectives in order to emphasize the relationship between data collection and management program. The first three objectives derive from early NPS legislation and general NPS policies and concern the assessment of resource state and trajectory and analysis of visitor impacts. These are followed by four objectives based on the analysis of threats to park resources: exotic species, change in natural processes, air quality, and impact assessment. Next come two objectives related to vulnerable resources: rare species and special protection areas. Finally, there are six objectives derived from the Biosphere Reserve Program. These objectives interrelate (for example, the objective of understanding ecosystems is related to the provision for understanding air quality

Table 3. Priorities for natural resource issues from GRSM Resources Management Plan (1984). Numbers in parentheses are the statement number from the RMP.

Most Significant	Important	Lower Priority
Exotic hog management (24)	Cave management (16)	Mt Lion monitoring (19)
Brook trout management (Ø3)	Fire management (11)	Bald eagle monitoring (Ø6)
Water quality (Ø2)	Red-cockaded management (18)	Fisher reintroduction (2Ø)
Exotic plant control (Ø8)	Peregrine restoration (17)	Frontcountry Manage. (13)
Special protection sites (25)	Pest management (14)	White-tailed deer (23)
Woolly aphid control (15)	Backcountry management (12)	Landscape Management (Ø9)
Air quality (Ø1)	Recreational fisheries (Ø4)	Balds management (1Ø)
Ecosystem analysis/monitoring (26)	Smoky Mt Madtom restoration (Ø5)	Hazard tree manage. (Ø7)
	River otter restoration (21)	
	Black bear management (22)	

Table 4. Plant ecology research projects from the GRSM Resources Management Plan (1984) (*=funded, **=recently completed projects).

RMP Reference Number	Short title
	UNDERSTAND AIR QUALITY EFFECTS
Ø1.4.C.1	*Assess spruce-fir decline
Ø1.4.C.2	Assess visible damage and remote sensing of stress
Ø1.4.C.3	*Assess sulfur accumulation in lichens
Ø1.4.C.4	**Assess visible ozone damage on white pine
Ø1.4.C.5	*Assess effects of ozone on genetic diversity in white pine
Ø1.4.C.6	*Assess effects of ozone and sulfur dixoide on rare plants
Ø1.4.C.7	**Study tree decline (FORAST)
	ASSESS AND CONTROL EXOTIC SPECIES
Ø8.4.A.2	Survey exotic plants in developed areas
Ø8.4.A.4	Develop identification pamphlet on exotic plants
Ø8.4.B.1	*Monitor exotic plant locations
Ø8.4.C.1	Survey exotic plant literature
Ø8.4.C.2	Document impacts of Japanese grass
Ø8.4.C.3	Evaluate exotic plant program
Ø9.4.A.2	Survey exotic plants in developed areas
15.4.B.1	*Monitor adelgid spray effects
24.4.C.1	*Develop hog rooting index
24.4.C.4	*Evaluate hog exclosures and Special Protection Areas
	RESTORE NATURAL PROCESSES
11.4.C.1	*Map, inventory, and classify fuels
11.4.C.2	Evaluate effect of felling dead Fraser fir on fuel loads
11.4.C.3	Continue fire history research
11.4.C.4	Understand fire behavior within the Park
15.4.C.1	Assess fuel loadings and effect on Fraser fir communities of stress
	MONITOR VISITOR IMPACTS
16.4.C.1	Monitor visitor impacts for carrying capacity studies
	MAINTAIN SPECIAL PROTECTION AREAS
1Ø.4.B.1	*Monitor grassy balds response, including rare plants
1Ø.4.C.2	Monitor balds restoration and test fire for maintanence
25.4.C.1	Design monitoring strategy for and evaulate significance of Special Protection Areas
	PERFORM BASELINE STUDIES AND LONG-TERM MONITORING
26.4.C.1	Develop long-term ecological monitoring strategies
26.4.C.2	Initiate baseline studies
26.4.C.3	*Utilize remote sensing for a Park vegetation map
26.4.C.4	*Develop a Geographic Information System
26.4.C.5	**Map disturbance history
26.4.C.6	*Continue bibliography series
	PROTECT RARE SPECIES
26.4.C.7	Map rare plants
	PROTECT UNIQUE GENE POOLS
1Ø.4.C.1	Evaluate the role of balds in azalea gene pool diversity
	MISCELLANEOUS
Ø7.4.C.1	Assess defect conditions in hazard trees
Ø9.4.C.1	Establish more efficient management on roadsides, vistas, etc

Table 5. Fifteen general categories of National Park Service management objectives that determine research objectives (*=derived from specific legislation or other policy document--see text and Table 1).

OBJECTIVES
OBJECTIVES RELATED TO BASIC NPS LEGISLATION
Inventory resources
Understand ecosystem and landscape structure, function, and dynamics
Minimize visitor impacts
OBJECTIVES RELATED TO SPECIFIC THREATS
Restore natural processes
Minimize exotic species impacts*
Understand and minimize the effects of atmospheric deposition*
Prevent adverse impacts of Park management*
OBJECTIVES RELATED TO VULNERABLE RESOURCES
Protect unique areas (special protection areas)
Protect rare species*
OBJECTIVES RELATED TO THE BIOSPHERE RESERVE PROGRAM
Develop strong research management
Develop a long-term and holistic research strategy
Participate in comparative studies
Participate in monitoring networks
Perform research in conservation biology
Protect genetic diversity

Table 6. General management objectives and major categories of plant ecology research in GRSM.

PLANT ECOLOGY RESEARCH AREA (PROJECT REGISTER ABBREVIATIONS IN PARENTHESES)	RESEARCH RELATED MANAGEMENT OBJECTIVES: Resources basic inventory	Ecosystem analysis	Restore natural processes	Exotic species	Unique areas	Visitors impacts	Effects of air quality	Rare species	Impacts of management	Research management	Long-term, holistic research	Comparative studies	Monitoring networks	Conservation research	Genetic diversity
THREAT RELATED															
AIR QUALITY (AIR)		X			X		X	X			X	X	X		X
BASLAM WOOLLY ADELGID (BWA)				X											X
ENVIRONMENTAL IMPACTS (EIS)					X			X	X						
EXOTIC PLANTS (EXPLANTS)				X											
FIRE ECOLOGY (FIRE)		X	X		X					X					
GRASSY BALDS (GRASSYB)	X				X			X				X			X
EUROPEAN WILD HOG (HOGS)				X	X			X		X					
RARE PLANTS (RARE)	X				X	X	X	X	X						
PINE BEETLE (SOPINEBE)		X													
VISITOR IMPACTS (VISIMP)					X	X		X	X						
BASE LINE DATA/RESOURCE BASIC INVENTORY															
BIBLIOGRAPY (BIBLIOG)										X					
DISTURBANCE HISTORY (DISTHIST)	X	X	X												
FLORA (FLORA)	X														
VEGETATION PATTERN (GENVEG)	X	X													
GEOGRAPHIC INFORMATION SYST (GIS)	X									X					
PERMANENT PLOTS (PERMPLOT)	X	X			X	X	X	X		X	X				
VEGETATION MAP (VEGMAP)	X	X													

effects and virtually all projects support resource basic inventory). The three broad groups of management objectives show the evolution from within-park concerns, to recognition of specific threats and vulnerable resources, and finally to national parks as part of an international conservation strategy.

Table 6 compares the 17 major resource management issues (all but three are equivalent to project statements in the GRSM Resources Management Plan) to the 15 general research-related management objectives. Most management objectives are supported by more than one project area. For example, air quality research addresses many objectives because of the pervading nature of this problem (indeed, research in the park is addressing air quality effects on rare plants, genotypes, unique resources, and this research is resulting in baseline studies and resource basic inventories). The major resource management issue concerning the restoration of natural processes is fire ecology. Major exotic species research concerns the balsam woolly adelgid and European wild hog. Long-term studies, in the form of permanent vegetation plots, have been initiated in the air quality area, in fire effects, and in European wild hog effects, but only in the area of air quality have these been holistic in approach.

The 15 research-related management objectives define a large area of interest. The particular kinds of objectives often compete with one another for research support and each of these general categories (e.g., air quality effects) contains competing specific projects. In addition, other research objectives are not contained in the current Resources Management Plan (e.g., the proposed Biosphere Reserve projects). I will return to a statement of research objectives and priorities in the final section of this paper.

ADMINISTRATIVE HISTORY OF SCIENCE IN GREAT SMOKY MOUNTAINS NATIONAL PARK AND THE DEVELOPMENT OF THE PLANT ECOLOGY RESEARCH PROGRAM

Establishment and Administrative History of the Science Program

Historically, the National Park Service has experienced three broad phases of scientific research: an early period of resource inventory and baseline studies, sometimes including the definition of critical, usually wildlife-related management issues (ca. 1916-1940); a period of decreased research effort (ca. 1940-1963); and a period marked by increased efforts to establish research as an integral part of NPS operations (ca. 1963-present) (Dennis 1985, Sumner 1983). With particular reference to Great Smoky Mountains National Park, these three periods are described as follows:

(1) 1934-1940. The period of resource inventory. With the establishment of a number of parks in the 1930s (including Great Smoky Mountains National Park in 1934), there was a period of National Park Service-sponsored research to inventory the newly acquired resources. In GRSM, animal and plant surveys were carried out and the vegetation was surveyed and mapped.

(2) 1940-1970. The naturalist period. Arthur Stupka, Park Naturalist, compiled species checklists and a journal of natural history events. There was a growing awareness of resource threats (e.g., succession on grassy balds) and some NPS sponsored research. University research was strong during this period, but the major emphasis was the use of the park as an undisturbed, old-growth study area for basic research (the research generally concerned non-applied issues--in GRSM grassy balds research was a notable exception (e.g., Gilbert 1954)).

(3) 1971-present. The period of in-house science (beginning with the hiring of the first Chief Scientist in the Southeast Region in 1971). Some Park Service sponsored research was carried out before the establishment of Uplands Field Research Labatory in 1975; the science program grew quickly thereafter.

In the early 1970s, increasing concern over the threats to GRSM led to an increased National Park Service research effort in the park. It was clear from the beginning that GRSM was popular as a research site among academic scientists; it was also clear that management questions were not being addressed by the outside research community and that an on-site program was needed to carry out NPS-oriented projects, interface research results with managers, and interact with outside researchers. One of the first issues studied in GRSM through the Southeast Regional Office concerned the effects of acid drainage from road fill derived from the Anakeesta Formation. Perhaps the most pressing issue when Uplands Lab was founded was the need to understand the ecology and impacts of the European wild hog, but it was clear that a variety of other management issues needed to be addressed.

In 1974, G. Smathers, then Chief Scientist at the NPS research station at Bay St. Louis, Mississippi (this Unit was to close soon thereafter), with the Regional and Washington Office of the National Park Service,

established a Cooperative Park Studies Unit (CPSU) at Western Carolina University. Ray Herrmann, Chief Scientist in the Southeast Regional Office from 1973 to 1979, recruited Susan Bratton as the first NPS staff member at Western Carolina. Bratton had just completed her Ph.D. dissertation on understory plant communities (Bratton 1975) under R. H. Whittaker at Cornell University. While carrying out this work, Bratton worked on the impact of European wild hog on the high elevation beech forests of the park. Bratton subsequently moved to an office at Tremont in the park and founded Uplands Field Research Laboratory (1975). Later in 1975, Uplands Lab was moved to the old Superintendent's residence at Twin Creeks (these quarters were made available by Park Superintendent Boyd Evison). Smathers eventually moved to the Western Carolina CPSU, with major research emphasis on the Blue Ridge Parkway, but that unit closed in 1983.

Uplands Field Research Laboratory was initially administered by the Southeast Regional Office. The research mandate strongly emphasized Great Smoky Mountains National Park (the second largest park in the Southeast), but the name of the unit was meant to portray a larger focus (i.e., non-coastal parks in the "upland" areas). Although several projects have been carried out in other Southeast Regional parks by the Uplands staff (see below), the program has always been heavily oriented toward GRSM. Administration of the Lab and funds to support permanent staff were transferred to Great Smoky Mountains National Park in 1979 by Chief Scientist Jay Gogue, although the National Park Service component of the research budget still comes from the Regional Office's science funds. Within the administrative structure of GRSM, Uplands Field Research Lab eventually became the Science Division of the park (1983). In 1985 a Cooperative Park Studies Unit was established at the University of Tennessee in Knoxville. This unit now functions as a university office of the Science Division.

In the same year that Bratton founded Uplands Field Research Lab, she initiated the first of a series of Annual Science Meetings (1975). This annual meeting serves as a forum for the presentation of research results and for scientists to meet park staff and to participate in workshops on particular topics of interest to the park. Over the last 11 years, 233 abstracts have been presented in plant ecology-related subject areas by 85 investigators from 47 institutions (including 9 National Park Service units, 8 other Federal agencies, 3 state government offices, and 25 universities). The most important subject areas have been: general vegetation structure and dynamics (67 abstracts), air quality related research (30 abstracts), European wild hog research (20 abstracts), endangered species research (19 abstracts), and fire ecology research (13 abstracts). Thirteen discussion workshops on plant ecology-related subjects have been held (Table 7).

Development of the Vegetation Research Program

A complete chronology of plant ecology projects that have directly involved National Park Service personnel or resources or have been carried out in close cooperation with Science Division staff is presented in Table 8. These projects fall into 12 major research areas: impacts of the European wild hog, management on grassy balds, impacts of the balsam woolly adelgid, understanding of fire ecology, development of a geographic information system, mapping of vegetation, mapping of disturbance history,

Table 7. Plant ecology-related workshops held or reported on (*) at the Annual Science Meeting in Great Smoky Mountains National Park.

1975
Rare, endangered, endemic species and unique habitats: special protection problems within GRSM
Management needs and resource inventory: establishing a data base for management in GRSM
1976
Biosphere Reserve status for GRSM
1977
Vegetation mapping and survey
1978
Monitoring
1979
Natural disturbance in plant communities of GRSM
Impacts of European wild boar in GRSM
1980
Rare and endangered species: how secure are they in GRSM and surrounding areas
1981
Air pollution and monitoring effects studies in the southern Appalachians
1982
Air quality research in the southern Appalachian mountains
Acid precipitation effects research
1983
The southern Appalachian spruce-fir ecosystem (White 1984)
1984
*Control techniques for wild hogs (Tate 1984)
1985
Geographic Information Systems in the GRSM region

Table 8. Chronological listing (by year of initiation) of plant ecology projects in the GRSM Science Division.

Year	Project
1975	Computerized checklist of vascular plants
	Survey of 5 exotic plants in the Tennessee district
	Secondary succession in spruce-fir forests
	Winter rooting activity in European wild boar
	History, succession, and management of grassy balds
	An assessment of the environmental impacts of LeConte Lodge
1976	First hog exclosure study
	Disturbance and visitation on Mt LeConte
	Fraser fir, its demise by the balsam woolly aphid
	Visitor impacts on backcountry trails and campsites
	Distribution, dynamics, and dimensions of forest fuels
	Trace element concentrations in soils and vegetation
	Environmental assessment of the proposed Blue Ridge Parkway extension
1977	Permanent plots: Cades Cove and western GRSM
	Investigations of special protection areas
	Impacts of an agricultural area within a natural area
	High elevation forage relationships of European wild boar
	Home ranges and habitat use of European wild boar
	Compilation of rare and endangered plants
	GRSM fire history and documentation
	Environmental assessment of the proposed Foothills Parkway
	Checklist of fungi
	Vegetation map: Mt LeConte growth district
1978	Permanent plots: logged and unlogged vegetation in western GRSM
	Permanent plots: western GRSM and fire effects
	Permanent plots: white-tailed deer and cattle impacts
	Permanent pltos: backcountry campsite impacts
	Flora and vegetation of limestone areas, Lower Abrams Creek, and other special floristic areas
	Ecology of Gum Swamp
	Analysis of Miller data
	Comparison of surface impact by hiking and horseback riding
	Rooting impacts of the European wild boar during a year of mast failure
	Bibliography series
	Bibliography of southern Appalachian vegetation
	Revised checklist and vascular plant data base
1979	Permanent plots: special protection areas and limestone vegetation
	Permanent plots: Mt LeConte
	Permanent plots: vegetation patterns a half century following chestnut blight
	Rare and endangered vascular plants: survey and monitoring

Table 8 (cont'd)

Location of CCC Camps in GRSM
Vascular plants of the grassy balds
Bibliography of southern Appalachian phanerophytes
Bibliography of southern Appalachian pteridophytes

1980 Computerization of herbarium label data
Botanical assessment of Shiloh National Military Park
Historic vegetation: Ft Fredericka National Monument
Exotic plant surveys: four southeastern Parks
Kudzu eradication experiments
Patterns of scientific research in National Park Biosphere Reserves
Survey of botanical information needs in the Southeast Region
Vegetation maps: Camels Hump and Huskey Branch
Impacts and influences on GRSM
Decomposition of standing dead trees
Landslide vegetation

1981 Earthwatch studies: Cladrastis, Cacalia
Effects of poaching on populations of rare plants
Permanent plots: prediction of stand growth increment
Second wild hog exclosure study
History and bibliography of scientific study
Vegetation map: heath balds and high elevation openings
Vegetation map: spruce-fir
Some ecosystem responses of wild boar rooting in a deciduous forest
Nitrogen dynamics of forest ecosystems in GRSM
Inventory of Air Quality Related Values in GRSM
The design of nature preserves: considerations of boundary placement and insularity
Bibliography of geology and geomorphology

1982 Earthwatch studies: Azaleas, grassy balds flora and succession
Permanent plots: data curation and management
Permanent plots: inventory of forest fuels
Monitoring of the balsam woolly adelgid control program
GRSM cartographic data base
Vegetation mapping using remote sensing
Acid rain and gaseous pollutant effects on lichens
Lichens of the Air Quality Class I National Parks
Flouride survey of vegetation and soils of the Cades Cove area
Sensitivity of NPS Class I Areas to atmospheric pollutants
Lead in vegetation, forest floor, and soils of the spruce-fir zone
Island biogeography of the high peaks
Analysis of forest growth response to air pollution stress
GRSM disturbance history: analysis of archival maps and records
Environmental monitoring and data management strategies
Effect of wild hogs on tree growth: an alternative hypothesis
Bibliography of southern Appalachian lichens
Bibliography of southern Appalachian soils

1983 TVA Raven Fork study
A genecological evaluation of air pollution tolerance in hardwood trees

Table 8 (cont'd)

	The effect of balsam woolly adelgid infestation on fuel levels
	The effect of southern pine beetle infestation on fuel levels
	Gypsy moth vulnerability and susceptibility ratings
	The GRSM hard mast survey: an evaluation
	A survey of growth trend decline in spruce
	Ethnobiology of the southern Appalachians
	Mapping elemental concentrations with lichens
	Effects of ozone and other pollutants on native and rare plants
	Data base on wild hog food items
1984	Permanent plots: spruce-fir
	Soils survey: spruce-fir
	Biomass distribution in spruce-fir forests
	Effects of atmospheric deposition and balsam woolly adelgid on Fraser fir
	Multi-elemental analysis of soil, litter, and vegetation
	Observations of boreal montane forest decline--soil and vegetation studies
	A lichen and bryophyte ecological baseline study in spruce-fir
	Establishment and assessment of white pine biomonitoring plots
	White pine genetics and ozone
	Development of a European wild hog rooting index
1985	Vegetation mapping: remote sensing project at UTennessee
	SARRMC spruce-fir ecosystem assessment program:
	Aerial survey
	Mycorrhizae, pathogens, and insect pests
	Forest modelling
	Dendrochronological validation and stem analysis
	Soil and plant tissue analysis
	Historical data base and land-use compilation
	Site characterization and permanent plots
	Nitrogen transformations
	Biomonitoring at ozone stations
	Model of balsam woolly adelgid-Fraser fir interactions
	An ecological information systems for GRSM
	Permanent plots: prediction of forest growth on disturbed sites in GRSM
	Effects of atmospheric deposition on canopy and soil processes and elemental cycling

establishment of permanent plots, impacts of the atmospheric deposition of pollutants, inventory of special protection areas, inventory of rare species, and conservation biology. An assessment of research results is presented in the next section. Below I will describe the historical development of the program.

The plant ecology program began in 1975 with four major projects: impacts of the European wild hog (Bratton), effects on Fraser fir of infestation by the balsam woolly adelgid (contracted to the University of Tennessee), management of grassy balds (contracted to Cornell University, but carried out under the supervision of Bratton), and survey of visitor impacts (Bratton). The last three of these areas, as originally formulated, had been successfully concluded by 1978. The hog project has proved more challenging. An ongoing hog exclosure project (P. White, L. A. Renfro) was initiated in 1981 (with exclosures established in 1981, 1983, and 1984), after an earlier exclosure experiment (Bratton, F. J. Singer) had failed due to several design problems. A significant new initiative in wild hog impacts was the attempt to formulate a park-wide rooting index for monitoring hog damage (C. Eagar, 1983). A reassessment of the park's mast survey was also carried out (N. Nicholas, 1983).

Beginning in 1977 and 1978, the major emphasis in plant ecology shifted to fire effects (M. Harmon) and permanent plot establishment (P. White, S. Bratton, and M. Harmon). The permanent plots were explicitly established to assess specific resource changes (hog rooting, deer browse, visitor impacts, and fire ecology), but they were based on a common study plan and thus initiated the capability for long-term monitoring (this project eventually resulted in the establishment of some 330 vegetation plots). The fire history work later contributed to the construction of a full disturbance history for the park (1983-1985). Research on organic fuels was initiated in 1977 by Harmon. After Harmon left in 1980, Nicholas continued the fuel surveys, at first without NPS support as a graduate student at the University of Tennessee. She later (1983-1985) completed the basic fuels inventory with funding from NPS. Harmon started fire effects research in 1977 and has continued to monitor several permanent plots in western GRSM.

In 1979, permanent plot establishment shifted to the sites of special protection areas (e.g., limestone areas and Mt LeConte). A major effort to inventory the park's rare vascular plants (1979-1982) was started by White. This project was later supported by Earthwatch and involved several subprojects (e.g., effects of grassy balds succession on plant diversity; White, Renfro) and permanent population plots. The rare plant project also resulted in a new vascular plant checklist for the park and an extensive computerized data set, which in 1983-1985 was used as a basis for a survey of ethnobiology through a grant from the NPS MAB Coordinator.

In 1981, Bratton and White were funded by the U.S. MAB Consortium to complete a research project on the effect of park design principles on conservation planning. The project supported two Ph.D. research projects at the Unversity of Georgia: one on the relationship between species diversity and the number, size, and habitat complexity of simulated "parks" (R. Miller) and the second on ecological measurement of park boundary effects (J. Ambrose). The first of these used the park's rare plant data base and the TVA Natural Heritage data base.

Starting in 1980, important changes occurred in the park's science staff. Harmon left for Oregon State University in that year. In 1981, Uplands Lab Research Coordinator Gary Larson transferred to the Midwest Regional Office of the Park Service and Bratton transferred to the CPSU at the University of Georgia. White took over the program from Bratton and was acting Research Coordinator until spring 1982. This decrease in staff from three lead investigators to one (who had a heavy administrative load) effectively suspended the permanent plot program (it was to be revived in connection with the air quality effects work in 1984). Mark MacKenzie was hired in 1981 to assist in data management on the permanent plot program and to work with a data set from the 1930s vegetation survey (the "Miller" data).

A major new initiative in the plant ecology program for 1981-1982 was vegetation mapping. This project began with interpretation of aerial photographs and the first modern all-park vegetation maps were completed (C. Eagar, D. Stratton, P. White). In 1982, through funding from the NPS MAB Coordinator's office, a remote sensing project was initiated with the Denver Service Center. This project included the development of a digital cartographic data base for the park (this element was soon completed), but the remote sensing project ran into problems at the Denver Service Center and was transferred to the University of Tennessee in 1985 through special funds received from the NPS Washington Office. This project uses aerial photographs, 15-m resolution aircraft collected data, 30-m resolution Thematic Mapper Satellite data, and 80-m resolution LANDSAT data to map the park's vegetation. The vegetation map/geographic information system project became a common element for several contemporary projects: disturbance history (C. Pyle) and fuels survey (N. Nicholas) were carried out in 1983-1985 to add mappable information to this data base. The disturbance history work was continued under a U.S. Forest Service grant to P. White and T. Wentworth (N.C. State) as part of the SARRMC spruce-fir ecosystem assessment program.

The fastest-growing area of plant ecology research has been in air quality effects, which began to increase in importance in 1983. The NPS Air Quality Divison (under J. Bennett) has funded much of this work, with most projects carried out under contract to outside researchers (see below and Appendix I). A major grant of U.S. Forest Service funds was obtained in 1984 (to P. White and C. Eagar) to establish permanent plots in the spruce-fir zone in the SARRMC spruce-fir ecosystem assessment program. This project consists of eight individual research topics (Appendix I, under AIR-SARR).

The current (1986) focus of the plant ecology program is on (1) the vegetation mapping/geographic information systems project (a key resource tool needed in several other projects); (2) the effects of air quality on plant populations, communities, and ecosystems; and (3) the analysis of wild hog impacts through exclosure experiments. In 1986, P. White left NPS for the University of North Carolina. He is completing analysis of data from the 1981-1986 hog exclosure project and is involved in several other GRSM projects due for completion in 1987.

Between 1979 and 1982 Uplands Lab personnel worked on or supervised several plant ecology projects in other Southeast Region Parks. These

included a botanical assessment at Shiloh National Military Park (P. White and R. Jones of Vanderbilt), exotic plant surveys at four parks (S. Bratton, D. Stratton, T. Butler), and biological assessments at three parks (P. White, S. Bratton, G. Larson). P. White currently supervises the completion of a rare plant survey at Cumberland Gap National Historical Site (contracted to L. Pounds and T. Patrick).

Plant Ecology Projects in Management Phase

Since establishment of the science program in GRSM, research projects have contributed to management in five key areas. The most conspicuous of these is in the grassy balds management, where research tested the efficiency of several balds restoration and maintenance techniques. The park began restoration of two balds in 1983. Recognition of the importance of this program has come from other federal and state agencies that manage balds. A second area of management use of research data is in air quality effects. Although most of this research is ongoing, data have been used in testimony before Congress on air quality impacts and in the permit review process for new pollution sources in the vicinity of the park. Data on wild hog impact have been used repeatedly to justify the importance of upgrading the management effort on these exotic animals and a research project designed to improve the park's mast survey program has been directly used by the Resource Management staff. The campsite and trail survey also led to management actions, including limits to the number of campers per night and closing of some campgrounds.

Data from the rare plant survey were cited in the park's General Management Plan and have been used on over twenty occasions for biological assessments of proposed park developments. This data base has also been used on numerous occasions in Section 7 consultations with the U.S. Fish and Wildlife Service, as specified in the Endangered Species Act. Research on visitor impacts on rare plants on Mt. LeConte led directly to added protection for one high elevation cliff site. Research on rare plant populations and special protection area surveys was used to describe these areas in the Resources Management Plan.

Data developed at Uplands Lab were used in the formulation of the park's General Management Plan. In the Lab's early years, two environmental assessments were carried out (for the proposed extension of the Blue Ridge Parkway from Oconaluftee to Deep Creek and for the Foothills Parkway) and their data were used in formulating park development decisions. Science program staff have also assisted Resources Management and Ranger Division staff in the design of monitoring programs on exotic plants, the balsam woolly adelgid spraying program, and visitor impacts.

Reassessment of the 1976 Problem Definition

Bratton (1976) recognized three categories of priorities in GRSM research (Table 9): (1) problems defined by a major loss of resources, poor information base, and the need for immediate attention; (2) problems defined by basic resource inventory needs, partially successful management, and unknown severity; and (3) a low priority category in which present research was deemed adequate for park management needs. In the first category were two exotic species problems, the European wild hog and the balsam woolly adelgid. Research on the balsam woolly adelgid was completed

Table 9. Plant ecology research priorities from Bratton (1976).

Descriptive Title	Comments
First piority problems. Major loss of resources, poor information base, immediate attention needed.	
I. European wild hog research	
Estimate hog population size	Unsucessful
Develop hog population model	Basic biology of the animal complete; model not yet developed
Design better hog traps	Completed, but group traps did not prove useful
Develop selective baits	Currently being carried out
Hog behavioral work	Completed, but results showed much complexity
Hog damage and recovery in plant communities	Earlier project partially successful; ongoing
Food habit study	Completed
Effects on soils, erosion, siltation	Partially complete; not yet addressed on whole catchment basis
Parasites and diseases	Not carried out
II. Balsam woolly adelgid--population expansion and damage to Fraser fir	
Literature review	Completed
Distribution in Park	Completed
Evaluate aerial photography	Completed
Assess vegetation impacts	Completed, needs update
Second priority problems. Basic resource inventory, areas where management is already partially successful, areas where severity is unknown	
I. Basic resource inventory	
Geographic information system	Ongoing; earlier project failed
Vegetation map	Ongoing
Mast survey	Recently reevaluated; management program in place but improvement depends on completion of vegetation map
II. Rare, endangered, endemic, and extinct species	
Inventory, mapping and monitoring of rare plants	Completed except for report
III. Human interference and impact on natural ecosystems	
Hiker impact	Completed; recently repeated for AT
Impact of illegal and indiscriminant plant collecting	Partially complete
IV. Fire control	
Map fires and fuels	Partially complete
V. Pine bark beetle damage	
Succession after beetle attack	Completed
Third priority problems. Present research adequate for management needs of Park.	
I. Maintanence of grassy balds	Completed
II. Exotic plant distribution	Completed, but needs update
III. Acid pollution of streams (Anakeesta)	Completed

through contracts with R. Hay of the University of Tennessee. However, a 10-year update on these studies and a more holistic approach to ecosystem change in the high elevations is desirable; some of this will be accomplished through the spruce-fir ecosystem assessment program. Another critical question concerned the probability of Fraser fir extinction (R. Gardner, D. DeAngelis, and V. Dale of Oak Ridge National Lab are working on a model of the Fraser fir/balsam woolly adelgid interaction); research to develop methods for preserving this gene pool is of high priority. Because of deposition of high levels of atmospheric pollutants, spruce-fir forests are the major focus of current air quality research projects.

Work on the European wild hog has proved to be more difficult and less successful. Hog biology, behavior, and food habits were assessed but proved variable (see Appendix II, index). Hog population size is still unknown, with attention now turning to monitoring hog damage rather than population numbers as a way of evaluating management effectiveness. Several population models have been developed (B. Dearden, pers. comm.; R. Barrett, pers. comm.; Tate 1984), but none have been accepted as valid for the park and this remains a proposed project area for 1986. An expanded bait study is now being carried out by G. Wathen at Uplands Field Research Lab. Hog damage to plant communities has been studied several times. As noted above, the first attempt to establish a hog exclosure project ended in 1979 with the breaking into the exclosures during a poor mast year; a second (ongoing) project was initiated in 1981 to pursue this effort. Recovery of plant communities in the absence of the hog is an important area for continued research. Hog effects on soils, nutrient cycling, and stream effects have been studied, but the project was carried out on a limited spatial scale.

Resource basic inventory projects did not begin until 1982. Vegetation mapping and the development of a geographic information system are subjects of ongoing work and remain high in priority. A reassessment of the park's hard mast survey was completed and is being implemented by management. Basic inventory projects have also been completed on rare species, visitor impacts, and on orchids subject to illegal gathering in the park.

Research on fire and southern pine beetle is related to the dynamics and regeneration of pine forest. We have attained a general understanding of both beetle and fire effects, but the use of prescribed wildfires or management-set fires awaits a better ability to predict fire behavior. This area remains a key priority and would fulfill mandates in both the Statement for Management and the General Management Plan.

Projects in Bratton's (1976) third category have been completed as originally designed. However, the exotic plant survey work was originally quite limited in scope and this problem has not yet been adquately described.

THE PROJECT REGISTER: AN OVERVIEW

The project register presented in Appendix I includes 345 plant ecology-oriented research projects carried out in the park since 1972. This register is based on the Annual Investigator Reports and Resource Activity Permits (formerly Collecting Permits) on file in the park's Resources Management Division, and on the records of the Science Division. The projects are arranged alphabetically within 37 major research areas, with the air quality area further subdivided into 7 categories. Assignment of specific projects to the 43 total categories necessarily included some arbitrary decisions and the project areas are, in many cases, interrelated. These interrelationships are listed in the variable "CROSSREF" in the data base (Appendix I).

The projects vary in significance, both scientifically and in terms of park research needs. For this reason, five variables were used to code the relationship of the projects to NPS resources (funding, personnel, facilities) and research needs:

"RMP" (Resources Management Plan) indexes the studies by statement number in the Resources Management Plan (1984). If the project is specifically listed in that Plan, the full statement reference is given (e.g., Ø1.C.4.1 for spruce-fir decline studies). If the project is related to the Resources Management Plan but not specifically listed (for example, if the project was carried out before formulation of the 1984 Plan or was funded outside NPS and therefore was not directly based on the Plan), then only the first two numbers of the project statement are given (e.g., Ø1 for air quality-related research). If the project is unrelated to specific statements in the Resources Management Plan and builds the information base of the park, then "BDATA" (for baseline data) has been entered in the RMP field.

"NOTRMP" codes studies that are not specifically listed in the Resources Management Plan ("1"=studies that are related to Plan statements and "2"=studies that are unrelated to Plan statements).

"GRSMSCI" codes the involvement of the GRSM Science Division in the project ("1"= the project involved Science Division staff, NPS resources, or was carried out with the close cooperation of the Science Division; the field is blank if this is not the case).

"INST" codes the institution of the investigators (for example, "NPS-UPL," "NPS-CPSU" for the Science Division).

"FUNDING" codes the source of the funding (for example, "NPS" for the National Park Service).

Of the 345 projects, 151 have involved National Park Service personnel or funding. All of these projects are listed in the current Resources Management Plan, in past editions of the Plan, or are closely related to project statements in the Plan. There have been 153 resource inventory projects (RMP="BDATA"). Of these, 137 have been carried out more or less independently of the National Park Service and are not specifically covered by Resources Management Plan statements.

The project register categories fall into four groups. First are 20 project areas related to direct resource change and threats: the seven AIR (air quality) project areas, BWA (balsam woolly adelgid studies), CHESTNUT (chestnut blight and related studies), EIS (environmental assessments of development), EXPLANTS (exotic plants), FIRE (fire ecology), GRASSYB (grassy balds restoration and maintenance), GYPSY (gypsy moth studies), HOGS (European wild hog impacts), LANDSL (landslide occurrence), PATHOL (plant pathology), ROADS (road corridor projects), SOPINEBE (southern pine beetle effects), and VISIMP (visitor impact assessments). The second group includes two project areas related to vulnerable resources: RARE (rare species protection) and SPECPROT (special protection areas). The third group includes 18 resource inventory, baseline, or monitoring project areas. Four of these have included mapping of park resources: DISTHIST (disturbance history), GIS (geographic information systems), SOILS (soils survey), and VEGMAP (vegetation mapping). Eight project areas concern basic understanding of the park's natural resources: BIGTREE (surveys of record trees), ECOSYST (ecosystem analysis), GAPS (gap phase dynamics of forests), GENVEG-A (studies of plant autecology), GENVEG-C (studies of vegetation pattern), MODEL (models of community and ecosystem dynamics), PALEO (studies of paleoecology), and PERMPLOT (permanent plots). Next is a group of six project areas related to the biological diversity contained in the park: BRYOPHYT (bryophytes), ETHNOBOT (ethnobotany), FLORA (vascular plants), FUNGI (fungi), GENDIVER (genetic diversity), and LICHENS (lichens). The final three project areas are: ISLANDS (tests of park design principles based on rare plants in the southern Appalachians), BIBLIOG (bibliography series), and GENERAL (general projects and overviews).

The following paragraphs review project areas in alphabetical order by project register code (thus, these descriptions appear in the same order as the projects in Appendix I). My purpose is to summarize what we have learned from these projects and emphasize the major issues. In a few cases I will refer to research needs, but that subject is more fully discussed in the last section of this report. Since the project register is confined to the last 15 years of research, earlier work is not reviewed (however, projects for which earlier work is relevant themselves include such a review). I will highlight only the most important studies in each section. I will not cite literature in this section--citations are given in the project register data base (Appendix I), with full references presented in the bibliography (Appendix II).

Air Quality-Related Project Areas (AIR)

The objective of the air quality-related research in plant ecology is to develop data on the impact of atmospheric deposition on park vegetation. This information will be used in the permit review process under the Clean Air Act and in affirmative action for improved air quality. Research in this area spans all biological levels of organization, from physiological effects to ecosystem processes. This is the fastest growing area of research in GRSM--hence, many of the projects listed under the seven "AIR-" subcategories below are ongoing and this summary cannot be detailed at this time.

Air quality-related ecosystem level projects (AIR-ECOS). The influence of atmospheric deposition on forest canopies and soil solution chemistry is being studied in three ongoing projects. From a conceptual and analytic point of view, the most important of these is the EPRI funded project by Johnson and Lindberg which is addressing the problem on an intensive spruce-fir study site on Noland Divide near Clingmans Dome. A key hypothesis of this work is that the soils in GRSM spruce-fir forests are near nitrogen and sulfur saturation; if this is so, additional inputs of nitrate and sulfate will potentially result in soil and watershed acidification, with the downslope movement of cations, including plant nutrients, and/or transmission of acidity to stream ecosystems. On a smaller scale, A. Stam is addressing the effects of precipitation acidity on aluminum availablity and the effects of acidity and aluminum on tree seedling growth in a combined lab and field experiment using intact spruce-fir soils.

Studies by the Tennessee Valley Authority (TVA) on Raven Fork are being completed this year. These studies address changes in chemistry of wet deposition as it moves through canopies and soils, and into stream ecosystems. Evidence to date shows a large effect of vegetation and soils on solution and stream chemistry, with post-storm event ground water from spruce-fir soils more acidic than water draining from northern hardwood stands, due to the greater acidity in spruce-fir organic horizons and less contact of groundwater with mineral soil under spruce-fir. These studies also show that soil properties (both chemistry and properties related to hydrologic pathways) dominate the response of groundwater and stream chemistry to storm events. However, these studies do not address larger atmospheric deposition questions, since dry deposition, canopy interactions, and origin of sulfate and nitrate in soils were not addressed. These processes will be described by the Johnson and Lindberg EPRI study.

Air quality-related research on lichens (AIR-LICH). Two lichen projects have been completed. Wetmore produced a preliminary checklist of GRSM lichens, annotated for pollution sensitivity. No field work was involved in this project, but with minimal effort (see also LICHENS, below) this work could be used to finalize and computerize a checklist of lichens for the park. The second completed project was a study by L. Sigal (ORNL) on spruce-fir lichens which described a possible decline in lichen cover in the spruce-fir zone and a decline in size and vigor of a species of Usnea. The Sigal results have been controversial and the data are regarded as preliminary.

Two other lichen projects by P. DePriest are in final stages of completion. The first of these was a park-wide survey to map elemental concentrations (e.g., sulfur) using one lichen species. The second project was a lichen and bryophyte baseline study carried out on the spruce-fir permanent plots and on rock outcrops of the high elevations. This study was designed to allow long-term trends in these groups to be measured.

SARRMC spruce-fir ecosystem assessment program (AIR-SARR). Great Smoky Mountains National Park protects the largest remnant block of undisturbed spruce-fir forest in the southern Appalachians. This high elevation forest is (or was until the influence of balsam woolly adelgid, an exotic insect, and atmospheric deposition) a biological and aesthetic centerpiece for the park. Approximately 75% of the park's major watersheds originate in spruce-fir forest. This forest is rich in rare plants and animals. In terms of value to the visitor experience, it has been shown that trail use is highest in the high elevations. Unfortunately, atmospheric deposition of pollutants is probably highest in this ecosystem type. The spruce-fir ecosystem is the focus of a number of the air quality-related studies; the SARRMC project represents the most broadly based and interdisciplinary of the projects. The drastic alteration of the spruce-fir ecosystem is one of the top conservation stories of this era.

The SARRMC spruce-fir ecosystem assessment program, the most important of the current terrestrial air quality-related projects in the park, got underway in 1985. It comprises eight core projects involving 17 principal investigators from 9 institutions: atmospheric deposition; aerial survey; soil and tissue chemistry; dendrochronology; modelling; mycorrhizae, pests, and pathogens; disturbance history; and vegetation structure, composition, and condition (see Appendix I). The eight core projects are organized around a network of permanent plots (at the three intensive study sites--GRSM, the Black Mountains, and Mt. Rogers and Whitetop, Virginia). Beyond these core projects are a number of "hypothesis-testing" grants, the only one of which currently underway in GRSM is on nitrogen transformations.

Products to date include a disturbance history report and an aerial photograph-based map of southern Appalachian spruce-fir forests showing pattern of mortality (mostly Fraser fir).

Air quality-related studies on trace elements (AIR-TRAC). Trace element work in the park began in the mid-1970s. An early EPA study (B. Wiersma and co-workers) reported that lead levels at one spruce-fir site were very high--and if valid would be among the highest values reported for a remote montane site. Because of this report, the survey for lead was expanded under R. Turner (ORNL). Although values were high enough for concern, they were only 10-25% of the values reported in the earlier study and are 25-50% lower than concentations in montane conifer forests in New England and western Europe. Given the lack of information on the effects of lead on forest trees and on the interaction of trace elements with other pollutants, however, it cannot be concluded that the current exposure to lead is harmless to these forests (indeed, the lead concentration differences with New England parallel the spruce dieback gradient). Lead concentration was shown to increase with increasing elevation.

McLaughlin and Baes (ORNL) studied trace element concentrations in

wood. They found that phloem levels of trace elements were 10-100 times higher than xylem levels and surpassed values known to be toxic to herbaceous plants for aluminum, cadmium, manganese, and nickel. Increases in aluminum, boron, cadmium, copper, iron, and nickel in wood since 1950 parallel increases in fossil fuel emissions upwind of the park. This correlation could be due to increased deposition of trace elements or their increased availability (which might itself be a secondary result of acid deposition). However, there was variablity among sites in these trends and no direct link can be presently made between regional deposition and xylem or soil concentrations. McLaughlin and Baes also reported higher levels of trace elements in wood formed during the operation of the Copperhill smelter (ca. 1880-1912) for trees in the western part of the park.

McNeil studied lead levels along the Newfound Gap road. He found levels higher than previously reported for non-major highways, but below those reported to be toxic to plants. However, the study was carried out in spring before peak traffic and levels along the road were variable and no higher than the control point selected.

Taylor and Parr (ORNL) recently found that flouride levels in the park were not high enough to warrant concern at this time.

Air quality effects on plant communities (AIR-VEGC). The most important work on plant community structure and air pollution is taking place in the spruce-fir zone under the SARRMC spruce-fir ecosystem assessment program. A project on white pine foliar injury is based on permanent plots and is reviewed in the next section. The only other project of significance was the survey of Air Quality Related Values performed by J. Skelly under funding from the NPS Air Quality Division in conjunction with a permit review. That study presented a preliminary list of forest types potentially sensitive to air pollution, based on the distribution of pollution sensitive trees.

Air quality effects at the physiological level (AIR-VEGP). Some genotypes of eastern white pine are sensitive to ozone. Skelly and others described white pine injury in the park in the late 1970s. Two white pine projects are currently being carried out in the park: by DeYoung and Sanchini (foliar symptoms and population permanent plots) and by Eckert (genetic diversity in eastern white pine as potentially affected by air pollution). DeYoung and Sanchini have confirmed widely distributed and signicant ozone damage to white pine (the report is in final review, and data cannot yet be cited). Eckert was able to show only a weak relationship between increasing ozone symptomology and reduced heterozygosity. Eastern white pine on his study sites showed low levels of genetic variability in general, a trend consistent with other studies of the geographic distribution of variability in this species. He found a strong correlation between site and symptomology, with damage increasing on more exposed sites.

Several other studies are ongoing and have produced only preliminary results: Karnosky and others on genetic diversity and pollutant sensitivity in eastern hardwood species (including red maple from the park); Reinert on pollution sensitivity of GRSM rare plants (a greenhouse study); Sanchini on ozone symptomology near ozone monitoring stations; and Clebsch and others on the interaction of pollution exposure and balsam

woolly adelgid effects on Fraser fir (a greenhouse study).

Esserlieu and Olson rated the air pollution sensitivity of Class I airshed national parks based on numbers of pollutant-sensitive species present. GRSM was ranked among the four most sensitive parks to pollution damage from ozone and sulfur dioxide.

Air quality projects related to tree or forest decline (AIR-VEGT). Six studies in GRSM have examined temporal patterns in annual growth increment in trees. Pioneering work was carried out by S. McLaughlin (ORNL) in conjunction with a extensive survey of eastern trees (FORAST--Forest Response to Anthropogenic Stress). This study did more than any other to increase our concern about the effects of air pollution on forests. However, the results proved controversial and are yet to be fully published. The FORAST project showed widespread growth decline in eastern tree species that began between 1950 and 1970 and paralleled increases in pollutant emissions. The controversy stems from several factors: (1) a measure of total growth (volume, biomass, basal area) is more significant than annual radial increment and may behave in ways not entirely predictable from annual increment at breast height; (2) trees are expected to slow in growth as they age, with each species differing in the timing and magnitude of this decrease even when other factors are held constant; (3) competition and stand density also affect annual radial increment and are difficult to control; and (4) the relationship between tree growth declines and emissions may be purely correlative.

Nonetheless, the FORAST project was important in focusing attention on the possible influence of pollution on tree growth and has resulted in the funding of numerous studies addressing the problems cited above. Nine species were sampled in the park: white oak, black oak, chestnut oak, white pine, shortleaf pine, tuliptree, red spruce, Fraser fir, and yellow birch. For the data set as a whole, four species showed an abrupt shift to slower growth rates that began about 1960: red spruce, Fraser fir, pitch pine and shortleaf pine (all but pitch pine were sampled in the park). For these species recent growth was down 39-51% compared to a reference period. Other conifers and hardwoods showed a gradual shift to slower growth rates over the last 20 years, with the magnitude of the decline varying from 7% (tuliptree) to 34% (black cherry). For the data set as a whole, growth declines were more prominent at higher elevations.

As a result of this work, McLaughlin and his collaborators were funded by the NPS Air Quality Division to carry out a more extensive survey of the red spruce growth decline on Mt. LeConte. This study found that percentage of trees showing decline increased with elevation (from ca. 10-20% of the trees at lower elevations to 50-60% at higher elevations) and that growth rate decreased with elevation (from a growth decline of ca. 10% at lower elevations to ca. 50% at higher elevations, when recent growth was compared to a reference period). This report also showed that growth decline on Mt. Sterling was more frequent in larger (ca. 50% showing decline consisting of a ca. 40% decline in growth rate) compared to smaller trees (30% showing decline, with an overall average growth rate increase of 1.5%). Growth decline was also documented in a planted stand of Norway spruce along the Grassy Branch trail.

Three other projects have addressed the issue of red spruce growth in

the park. Cogbill carried out an early study and concluded that no correlation could be established between trends in acid deposition and red spruce growth. Cook and others have collected red spruce cores in the park for dendrochronological studies but their results are unpublished at this time. Bruck and Robarge initiated a study of growth, mortality, soil chemistry, and tissue chemistry using a series of sites in the southern Appalachians. Six permanent plots (two on Mt. LeConte and four on Clingmans Dome) were established in 1984 and resurveyed in 1985. Preliminary results showed that 82% of all spruce experienced a depression in growth rates beginning in 1958-1963, that growth depression was more marked at high elevations and on west slopes, and that tree condition declined from 1984 to 1985.

Bibliographies (BIBLIOG)

Eight bibliographies have been produced including five on plant ecology-related subjects (Appendix II, Part C).

Record Trees (BIGTREE)

No complete survey or monitoring propgram has been conducted on the park's national and state champion trees. P. White has kept a file of these records on an ad hoc basis (including lists of large trees by species developed in the past by park interpreters and rangers). W. Korn conducted an apparently incomplete survey for Tennessee state record trees.

Bryophyte Ecology and Systematics (BRYOPHYT)

Several bryophyte studies are referenced under air quality projects, including the lichen and bryophyte baseline study by DePriest and an early use of mosses for trace element monitoring (Huckabee). Seven of the ten bryophyte studies specifically listed under "BRYOPHYT" have involved general collecting for distributional ecology and systematics. Two studies involved intensive investigations of bryophyte community structure (Huntzinger and Mescall).

A. J. Sharp, who has been at the University of Tennessee since 1929, is an internationally known bryologist. His bryophyte collections and publicatons, as well as those of his students, should be used to produce a park-wide bryophyte checklist. Such a list would be valuable in the analysis of species sensitive to pollutants, species known to be useful in biomonitoring, and rare species vulnerable to loss.

Balsam Woolly Adelgid (BWA)

Research on the infestation of Fraser fir by the exotic insect balsam woolly adelgid was a top priority issue when Uplands Lab was founded. Work contracted to R. Hay at the University of Tennessee documented the timing, pattern, and effect of adelgid infestation. Mortality of mature trees is essentially complete within 5-7 years of infestation. The highest summits with nearly pure Fraser fir stands maintained in a patchy state of fairly young stems by patchwise blowdown appear to have lower adelgid activity (the insect feeds in lenticels and bark fissures that develop as the trees mature). Fraser fir mortality began in the eastern part of the park in the 1960s; it has now progressed to the western limit of fir, with Fraser fir

mortality currently very high on Mt. LeConte and Clingmans Dome. Although a resurvey of long-infested areas for surviving adult trees and successional patterns has not been carried out in the park, mature Fraser fir trees seem to be suffering nearly complete mortality.

In 1982, the park began a program to protect stands of fir near the summit of Clingmans Dome using potassium oleate. Permanent plots have been established to monitor the effect of the spraying on adelgid populations and Fraser fir mortality. However, this monitoring effort was hampered by the lack of pre-treatment measurements and the lack of control plots in the earliest measurements; the post-spraying data on mortality rate of Fraser fir has not yet been reported.

In 1985, Fraser fir was listed as a candidate endangered species under the Endangered Species Act. The question of the long-term survival of Fraser fir is tied to the question of the dynamics of the Fraser fir-balsam woolly adelgid interaction. For example, since seedlings and saplings may survive in infested stands, and since the adelgid populations may decrease after mortality of larger canopy and subcanopy trees, there is a possibility that seedlings and saplings will reach seed-bearing age before reinfestation by the adelgid. This may be unlikely, but the question of the overall outcome of the Fraser fir-adelgid interaction and the timing of potential extinction are unsolved. As Eagar pointed out (see Eagar 1984, Appendix II), spread rates of the adelgid are dependent on wind direction and will vary geographically across the range. Under the terms of the DOE Exploratory Studies Program, R. Gardner, D. DeAngelis, and V. Dale at ORNL are developing a model of this interaction to test scenarios of Fraser fir endangerment. A second question relative to Fraser fir endangerment concerns the apparently adelgid-resistant genotype on Mt. Rogers in southwest Virginia. If this population proves to be genetically resistant, it could be used as a source of resistance for breeding with local GRSM gene pools.

The park has been used repeatedly as source of genetic diversity for Fraser fir (see GENDIVER, below).

American Chestnut and Chestnut Blight (CHESTNUT)

The American chestnut was once a widely distributed, large, dominant tree in GRSM. It was a consistent bearer of hard mast and was thus highly important as a source of food to the black bear and other wildlife species. Chestnut blight (an exotic fungus from east Asia) invaded the Great Smoky Mountains by 1920 and completely eliminated the chestnut as an important tree in the GRSM landscape by about 1940. Three projects on chestnut blight have been carried out recently, but none have yielded results useful to management. A fourth project concerned only recovery of forest stands 50 years after the blight (see PERMPLOT, below).

American chestnut root systems remain alive long after the original stem has died. These root systems give rise to periodic suckers that survive until they attain a size of 1-10 cm in diameter. The largest American chestnut trees occurred in coves and lower side slopes; it appears these larger trees have given rise to fewer root sprouts than those on the mid- and upper slopes. A few of these reach flowering age in the park, but since the tree depends on cross-pollination and the density of these

flowering trees is low, apparently no fertile seeds are produced in the wild. There is no official program in the park to map and monitor the surviving chestnuts that reach flowering size and age. Chestnut blight itself can infest oaks, although with much less mortality; hence, the blight has persisted even after the widespread loss of American chestnut. (This contrasts with the Fraser fir-balsam woolly adelgid situation, where adult tree root systems cease to be a source of living genetic material and where loss of adults may result in local parasite declines.)

Because living sprouts and occasional flowering trees currently represent a remnant of the American chestnut gene pool in the park, there has been a recent interest in preserving this gene pool before it is lost. The American Chestnut Foundation (Minnesota) has started a breeding program to isolate blight resistance factors from Chinese chestnut (a small tree that lacks the straight form of the American chestnut) and to introduce resistance into relatively pure American chestnut genetic stock through back-crosses.

Studies on natural and artificial selection for hypovirulent forms of the blight are continuing, although only one project of uncertain status was carried out in the park (Appendix I). Hypovirulence develops when a virus infects the blight fungus with genes that reduce the pathogenicity of the fungus. Several different viral strains vary in effect. Hypovirulent forms of the blight will slow the elimination to the chestnut gene pool. However, without a source of resistant genes, reestablishment of American chestnut as a forest tree will be impossible because the blight will persist and cause early mortality and deformity. Since the blight and viral parasite both have short generation times relative to chestnut, it is unlikely that the virus will reduce the blight to low levels. (It has been hypothesized that the blight and virus will co-evolve to a stable equilibrium of intermediate--not low--pathogenicity to chestnut.)

Disturbance history (DISTHIST)

Understanding disturbance history is basic to the understanding of park resources. Successional state affects (1) ecosystem processes (e.g., younger stands are still accumulating plant nutrients in biomass--the aggrading phase of ecosystem development) and thus affects the influence of atmospheric deposition; (2) stream chemistry and aquatic systems; (3) fuel levels and fire behavior; (4) landscape patterns and vegetation mapping; and (5) mast production and wildlife use. Understanding disturbance history is a key to designing sampling schemes for terrestrial vegetation. Although restoration of forests has never been a management issue in the park, several watersheds were severely disturbed by fires that occurred on logging slash and subsequent erosion. Forest cover is not fully reestablished on some of these sites after 60 years of recovery.

Charlotte Pyle recently completed an overview of the disturbance history of the park, based on archival maps and records and a review of previous publications (including important work in the W. McCracken's M.S. thesis at the University of Tennessee). Pyle added further detail to this work in the spruce-fir zone under the terms of a U.S. Forest Service grant (see AIR-SARR). M. Harmon and L. Barden analyzed the fire history of the park (see FIRE, below). The Harmon and Pyle data sets are being added to

the park's developing geographic information system data base.

Our data on disturbance history consists of the approximate locations of specific disturbances. However, the major kinds of disturbance--fire, farming, and logging--have had patchy effects. Even the most intensive logging sometimes left patches of older trees that were defective and patches of original forest on steep slopes. Old-growth forests near settlements had impacts caused by frequent but low intensity ground fires, occasional tree cutting, and free-ranging grazing animals. Thus, these maps will be refined as needed for specific study sites with additional analysis of aerial photographs and ground surveys.

Specific studies on succession after disturbance have included McCracken's work on logging (see GENVEG-C). P. White has collected data for a comparison of logged and unlogged watersheds in western GRSM (see GENVEG-C) and M. Harmon is studying fire effects (see FIRE).

Ecosystem-Level Projects (ECOSYST)

Most ecosystem-level research in the park concerns air quality effects (see AIR-ECOS and AIR-SARR above). Field work for a project on nitrogen dynamics in soil solutions by W. Swank at Coweeta (funded by the U.S. MAB Consortium) has been completed, but the report has not yet been finalized. In the context of impacts of the European wild hog, nitrogen was addressed by F. Singer, W. Swank, and E. E. C. Clebsch (see HOGS, below).

Environmental Assessments (EIS)

Two major environmental assessments were carried out by Science Divsion staff: on impacts of the proposed extension of the Blue Ridge Parkway from Oconaluftee to Deep Creek (this plan has been abandoned) and on impacts of the Foothills Parkway (under construction).

Ethnobotany (ETHNOBOT)

A MAB-funded study of the ethnobiology of the southern Appalachians was carried out from 1982 to 1985. This study was contracted to J. Campbell of Tennessee State University, under terms of the Historically Black Colleges Program. Research was carried out by Anita Bailey of Tennessee Tech and Gayle Darugh of the University of Tennessee at Knoxville. The final report is in review at this time. The project collated the available literature on the cultural uses of the region's diverse flora. The statistics were impressive: about 60% of the flora had at least one recorded use. The results of this project should be used in interpreting the importance of the park as a reservoir of genetic diversity in the southern Appalachian region (see also GENDIVER, below) and for developing living plant exhibits and landscaping around the park's visitor centers. This project, with the biological diversity data base described below (under FLORA), formed the basis of an international project to develop computerized inventories of biological diversity in Biosphere Reserves.

Exotic Plants (EXPLANTS)

Although good checklists have been constructed of exotic plants in the park, field surveys of exotic plant impacts in GRSM have been preliminary. An early survey of 5 woody exotics was confined to the Tennessee side of the park. In the context of the vascular flora data base, P. White presented an annotated list of exotics in 1982 (a separate appendix listed exotic plants known only at park developments) and this list has been used to prioritize exotic plants in the park by the severity of the threat they represent. The Resource Management staff is developing a program for exotic plant prioritization, control, and monitoring. D. Berg maintains an exotic plant data base for monitoring locations, population sizes, and management treatments.

Several exotic plants appear to be spreading in the park and may be impacting natural resources. Japanese honeysuckle has long been established here and management of this species should be reexamined. An only recently recognized problem, a Japanese species of grass, Microstegium vimineum, appears to be rapidly spreading in the park, but the rate of spread and impact are undocumented.

Fire History and Ecology (FIRE)

GRSM has carried out a policy of fire supression since the park was created. This has all but eliminated fire as an ecological force in the park; this represents a dramatic change from the pre-park landscape, when fire, probably much of it set by Native Americans and later by white settlers, was frequent (an average of 1 each 12 years of an intensity hot enough to leave fire scars on tree stems). The park has a draft fire management plan, which calls for zoning of the park into different fire prescription areas, but this has not been finalized.

We have a good understanding of recent fire history in the park, and some indication of fire effects. Much of this work was developed by M. Harmon, who continues to inventory several permanent plots that were placed on the site of a lightning fire in the western part of the park. These fires had hot spots that occurred on heavy fuel loads produced after southern pine beetle outbreaks and resulted in heavy pine regeneration. Fuels information has been collected by Harmon and by Nicholas. Harmon hypothesized that pre-park fuels were 60% of current levels due to frequent, low intensity, fires. He also hypothesized that fire suppression caused fuel levels to increase, but that, in this humid landscape with high producitivity and decomposition rates, fuel loadings have reached steady state except for high elevation pine forests (where the litter layer, fine fuels, and soil organic matter may still be accumulating) and for stands immediately after disturbances, such as windthrow or pine beetle attack. He also suggested that locally heavy fuels produced by disturbance, except perhaps for bole wood, constitute an opportunity for intense fire for only about 15-20 years.

N. Nicholas has completed a volumetric fuels survey for park communities and constructed a photo-guide (slide show) for this data set. Nicholas and White, in a study carried out to support the vegetation mapping effort, described the influence of insect attack on fuel loads: southern pine beetle resulted in three times higher fuels than in non-

infested stands (these fuel loads where among the highest in the park) and adelgid infestation resulted in two times higher fuel loads than uninfested stands. Long infested fir stands (17-23 years), however, had fuel loads similar to uninfested stands.

The question of fire policy has been considered by park managers to be related to the question of pine regeneration. Pine ecosystems are frequent in the park on upper slopes and ridges from low to mid-elevations. Without fire, pine regeneration occurs only on the driest sites; fires that are hot enough to expose mineral soil and cause mortality of competing hardwoods are necessary for pine regeneration on most sites. The result of fire supression is a current failure of pine regneration (relative to the amount of pine in the GRSM landscape) and the survival of hardwoods into fire-resistant size classes. Other species in pine ecosystems probably depend on these fires as well. Despite the emphasis on pine regeneration, natural fire had important effects in other forest types--even if the fire was not hot enough to cause pine dominance or to cause mortality in the overstory, these fires are a natural process that has been eliminated. However, one of the difficulties faced by managers is that the natural fire regime has been obscured by over 150 years of frequent human-set fires; thus, the "natural" process is difficult to quantitatively describe. Natural fire has not been important in the last five decades, but that time period is characterized by fire suppression and by fuel levels produced by a fire regime dominated by human influence.

Whether the goal of fire policy is to specifically maintain pine, to increase landscape diversity, or simply to restore a natural process, the information required by management is the ability to predict and understand fire behavior. The next step is to convert fuel volumes to mass (the inventories cited above were mostly volume estimates), understand fuel moisture behavior, and understand fire behavior in this complex landscape (using fires in experiments). The last issue is particularly important--it is unlikely much pine regeneration will occur unless intense fires are prescribed.

Vascular Plant Floristics and Systematics (FLORA)

The vascular flora of GRSM attracts a good deal of general collecting. Between 1972 and 1985, 42 separate projects were undertaken on vascular plants. The diversity of the park's vascular flora is world renown and is among the highest for all U.S. national parks (including some large western parks with elevational gradients wider than GRSM). Many species are genetically diverse in this landscape (see also GENDIVER).

A major effort to update the park's flora was carried out by P. White in 1979-1982, including extensive review of herbarium specimens at 10 herbaria and field work. This work produced in 215 additions to the known vascular flora of the park. The flora of special protection areas and other unique park habitats was inventoried. White also listed species in need of further taxonomic revision and geographic areas of the park that needed additional explorations. The flora of the park is thus well-known, but the complicated topography of the park, its size, and the current limits of our taxonomic understanding (a four-volume revised flora of the southeast is currently being produced by the University of North Carolina Press) means that we can expect to continue to further refine our

understanding of the park's vascular plants. However, a major effort is no longer necessary.

P. White also designed and implemented a vascular plant data base that consists of 115 variables for each of the park's 1500 species. These variables include such management-related information as exotic status, presence on national and state endangered plant lists, sensitivity to air pollutants, impact by the European wild hog, and distribution in the park. This data base was used as the base for the ethnobotany project (see above) and as a prototype for computerized inventories of biological diversity in biosphere reserves.

Systmatics and Ecology of Fungi (FUNGI)

Twenty-two collecting permits have been granted for systematic and ecological studies of fungi. Petersen updated the park fungi checklist in 1978 (including some 2200 species). He noted that GRSM was unique among large protected areas in publishing an inventory of these organisms and suggested the park maintain this unique position through periodic updates of the list. Mycorrhizal associations of fungi and vascular plants are fundamental to such management issues as air pollution effects (see AIR-SARR, above).

Forest Gap Phase Dynamics (GAPS)

The presence of large areas of virgin forest has made the park popular for studies of natural forest regeneration. Cove hardwood and hemlock-hardwood forests have been especially popular because of the large tree sizes, old aged stands, and lack of chestnut blight influence. L. Barden completed a series of studies on these forests between 1979 and 1982. J. Runkle is engaged in a longer-term study of these old-growth forests. J. Fox completed a project on spruce-fir dynamics; this work was followed up by P. White and others.

The consequences of this work for park management include the following. Gap phase dynamics imposes a level of patchiness on old-growth forests. Permanent plot monitoring strategies and the assessment of the influence of resource threats (like air pollutants, the European wild hog, and exotic plants) must take this patchiness into consideration. For example, younger stems in tree fall patches may respond differently to pollutant stress. Gaps also influence understory biomass and may affect patterns of wild hog rooting. It is more important to understand the influence of hogs on forest regeneration in gaps than in the forest understory (where the studies to date have been done). A final consequence of gap dynamic studies involves the park's record trees and virgin stands: are these in compositional and structural equilibrium or are the remnant areas too small, thus resulting in gradual loss of record tree sizes and only slow recovery?

Genetic Diversity-Related Studies (GENDIVER)

The concept of the park as a reservoir of genetic diversity is fairly new and is a strong part of the Biosphere Reserve program. Even before this concept was enunciated, however, the park was being used as a source of unique genetic material: for Fraser fir, champion trees, azaleas, seed

and germplasm distributions by botanical gardens (including the U.S. National Arboretum and Kew Gardens), international exchange (with Mexico, U.S.S.R., and China), and landscaping genetic stocks. Park mosses and lichens have been part of a National Institute of Health screening program for anti-tumor agents. Other studies have used the park in projects on the geographic distribution of genetic diversity in various plant groups. Although park scientists have facilitated this activity, much of this interest has developed independently of the Biosphere Reserve Program. This subject area could easily be developed to show the importance of strictly protected lands in the preservation of genetic diversity. Of direct benefit to the objectives of the park in protecting specific resources, would be the rescue of the Fraser fir, American chestnut, and grassy bald azalea gene pools.

General (GENERAL)

A heterogenous collecton of projects is listed in this category, including bibliographic and research surveys (see Appendix I).

Vegetation Structure and Compostion--Autecology (GENVEG-A)

The park has been the study site for eight studies at the autecological level. These have added to the descriptive understanding of park plant communities, but have not generated data with direct management implications.

Vegetation Structure and Composition--Community Level (GENVEG-C)

The general pattern of vegetation structure and composition in GRSM is well-known (there are 29 projects listed in this category in Appendix I and many more published items in Appendix II). Several questions have not been explicitly addressed, however, including: (1) patterns of succession on agricultural areas as a function of prior landuse; (2) mechanisms of enhancing recovery on watersheds heavily disturbed by logging slash fires and erosion; (3) geographic differences within the park, after site and other factors have been taked into account (North Carolina vs. Tennessee side of the park; the east-west gradient in the park); and (4) mechanisms of heath bald formation and maintanence. However, the basic research needs in this area relate to specific management issues and are listed under other categories (FIRE, SOPINEBE, HOGS, PERMPLOT, VEGMAP).

A large data set on the park's vegetation was created in the 1930s under the direction of F. Miller. This data set is the most extensive ever completed for GRSM and consists of 1,357 0.08 ha plots distributed throughout the park. Plot locations have been mapped and the data have been computerized. The summary of this data is important for understanding vegetation structure, composition, and distribution at the time of park creation and is being accomplished by M. MacKenzie in the context of his Ph.D. dissertation (see MODEL). The data can be used to describe the park's vegetation at the time of chestnut blight impact, at the time before fire supression had resulted in vegetation change, and at the time when recovery from farming and logging was beginning.

Geographic Information Systems (GIS)

We are currently completing a geographic information system for the park. Fifteen themes have been digitized, including streams, trails, campsites, developments, political boundaries, and monitoring sites. Available digital terrain maps have been acquired. Disturbance history information is currently being added. Vegetation data will be added as they become available. The focus of current work is to interface these data sets with park microcomputers (both in the sense of designing data bases for entry of additional themes and in the sense of the direct use of this data). This project will serve as a central tool in a variety of science and resource management efforts. An earlier project (1975, Su and others), contracted to NASA in Mississippi, was unsuccessful and the data set does not survive.

Grassy Balds (GRASSYB)

The history, composition, and successional dynamics of grassy balds in GRSM are well-known. A research project to test management alternatives was carried out and two grassy balds are currently being restored. The importance of grassy balds in floristic diversity has been studied. Park scientists and resource managers have also been involved in consulting with other agencies that manage grassy balds and the U.S. Forest Service is now working on a region-wide balds management plan. Because this community maintains diversity and aesthetics, because the balds are a distinctive feature of the southern Appalachians, and because of their human history, a regional approach to their management would be an excellent arena to demonstrate biosphere reserve objectives. An incompletely investigated issue on the grassy balds is the maintanence of the unique azalea gene pool that has developed there (see also GENDIVER).

Gypsy Moth (GYPSY)

The Resources Management staff (under D. Berg) has been monitoring gypsy moth presence using pheromone traps supplied by the U.S. Forest Service. Male moths have been trapped in 2 of the last 4 years but established populations are not yet present. A preliminary study was done to develop sampling procedures for the evaluation of gypsy moth susceptibility and vulnerability. Research on gypsy moth management is being carried out at several other parks. This species will likely become an important issue in GRSM within 5-15 years.

European Wild Hog (HOGS)

European wild hogs have been present in GRSM since about 1950. In high elevation beech forest, hogs reduce herbaceous plant cover by 70-95 % and alter its composition. Hog rooting mixes surface leaf litter and organic matter with mineral soils, speeding decomposition and reducing these soil layers. Diversity of food items found in hog stomachs is lowest where hogs have been present for the longest periods of time. Hogs eliminate microhabitats (rotting logs, leaf litter) for a variety of animal species. Hog wallows impact springs, seepage areas, and streamsides. Hogs depend heavily on the late summer and fall hard mast crop for winter survival and fecundity.

Hog impacts have been most intensively studied in the high elevation beech-dominated forests and have primarily been investigated with regard to effects on understory herbs (see Bratton's Ph.D. work). Impacts on forest regeneration have not been adequately addressed. A system of 12 hog exclosures has been established for the continued documentation of hog impacts and for research on recovery of high elevation forest understories (an older exclosure experiment failed in 1979--see above). The oldest sites have now been sampled for five years and an assessment of these data is now underway. A short-term study using an exclosure site was carried out on impacts on soils, animal populations, and nutrient cycling, but the potential for holistic studies remains unfulfilled.

A study by M. Lacki and R. Lancia from N.C. State proposed the hypothesis that hog rooting may increase growth rates for beech (through increased nutrient mineralization), but the interpretation of the data was complicated by the fact that sites with longest hog occupation where also at lower elevations (where the growth rate is higher because of longer growing seasons). Although hog rooting may increase mineralization through increased decomposition of organic matter, the nutrients in soil solutions may also be vulnerable to long-term loss through leaching. It has been suggested that hogs compete with native animals for mast during years of hard mast failure, but this has not yet been demonstrated. An important effort is now underway to develop a scheme for the assessment of spatial and temporal variability in hog rooting. If this proves successful, the park will be in a position to gauge the effect of management, weather, and mast failures on the amount of hog damage and will be able to more effectively indicate increases in damage in the eastern part of the park (where occupation is most recent), as well as the overall fluctuations in hog damage.

Island Biogeography (ISLANDS)

S. Bratton and P. White have carried out this MAB funded study on principles of preserve design. Two Ph.D. dissertations at the University of Georgia were funded through this work. R. Miller used the Tennessee Valley Authority's natural heritage data base and digital topographic maps to investigate the effect of size, shape, and number of preserves on protected southern Appalachian biological diversity (here equated with protecting rare plant populations because they are the most vulnerable components of diversity to loss). J. Ambrose is currently completing a dissertation on ecological measures of boundary effects.

Although this project was directed to a theoretical level, the data could be used as a foundation for a regional interagency approach to ensure the survival of the floristic diversity of the southern Appalachian region through the Biosphere Reserve Program.

Debris Avalanche and Landslide Studies (LANDSL)

The debris avalanches in the Mt. LeConte-Newfound Gap area have attracted the attention of geomorphologists and plant ecologists. In September, 1951, a dramatic series of over 200 debris slides occurred in the Mt. LeConte area. Such events are related to intense rainfall. Two ongoing research projects are investigating the mechanisms of avalanche occurrence and the historic frequency of these events. S. Feldkamp

completed work on plants found on the upper parts of avalanche tracks (see GENVEG). Influence of debris avalanches and flood scour downstream from severely eroded areas has not been addressed. Historic frequencies of debris avalanches and flooding as a natural disturbance have not been described.

Debris avalanches are frequent on Anakeesta bedrock in the central part of the park, in part because of the fine texture of the mineral soils and the steep slopes developed on this bedrock. This is an important management issue because of the instability of road cuts in this area and because exposed Anakeesta derived material acidifies soils and streams. The influence of Anakeesta road fill on park streams was an early research project in GRSM. Data have shown that use of Anakeesta in road fill severely impacts stream ecosystems. Natural debris avalanches may also cause stream impacts.

Lichen Ecology and Systematics (LICHENS)

We are close to a complete lichen checklist in GRSM. J. Dey completed a dissertation on high elevation lichens, and has continued to work in the park. C. Wetmore (see AIR-LICH) produced a preliminary list based on a literature survey. P. DePriest (see AIR-LICH) completed a M.S. thesis outside the park, but has been working on air pollution-related lichen projects here.

Simulation Modelling (MODEL)

Four versions of the FORET (Forests of East Tennessee) forest simulation model have been developed. R. Busing modelled the high elevation spruce-fir forests and predicted forest composition and structure under different scenarios and air pollution and adelgid effects. The model predicted that balsam woolly adelgid attack with moderate pollution stress would lead to spruce dominance (though with reduced growth rate and stem size) and that adelgid attack combined with severe pollution stress would lead to a low biomass, hardwood-dominated forest. The Busing version of the model was developed around a single spruce-fir site and has not been extended across topographic gradients, other disturbances (e.g., logging) or validated with independent data. M. MacKenzie is completing a dissertation to extend the model from individual sites to simulate landscape gradients in composition; this should refine the model's parameters to more closely simulate GRSM vegetation (he will use the F. Miller data set for model validation). In an earlier attempt, D. Weinstein worked on a version of the model that incorporated nutrient dynamics. He used data from M. Harmon to test fire effects, but results were poor except for cove hardwood vegetation. Another modelling effort has just been initiated in the spruce-fir zone (see Maguire, under AIR-SARR). This effort will be similar to Busing's model but will be verified based on more sites and disturbance histories and thus should prove more general.

A fifth modelling effort seeks to simulate the Fraser fir-balsam woolly adelgid interaction (see R. Gardner and others, under BWA).

Paleoecology (PALEO)

J. Davidson studied the last 6600 years of forest and landscape change in Cades Cove using sediment deposits. She documented the increased importance of pine in the last 2000 years that probably coincided with increased fire frequency due to human activities. G. Torbett studied rock fragments near Thunderhead Mountain that were used as evidence of alpine conditions and a climatic treeline 12,000-18,000 years ago.

Plant Pathology (PATHOL)

Several plant pathology-related projects have been carried out in GRSM. The most important management issues related to pathology have been described elsewhere (see AIR-SARR, BWA, CHESTNUT). We need a more complete perspective on natural and exotic organisms that cause tree stress and mortality, given the interaction of these species and other sources of stress such as air quality impacts.

Permanent Vegetation Plots (PERMPLOT)

Three hundred and thirty 0.1 ha permanent plots have been established by GRSM Science Division staff in the context of the following management issues: fire ecology, European wild hog impacts, campsite impacts, deer and cattle browse effects in Cades Cove, special protection area characterization, air pollution effects, and chestnut blight recovery. Although a subset of the plots were used for hog impact work in 1978-1979, there is no current NPS sponsored effort to periodically reinventory these plots. M. Harmon is studying fire effects on several plots. An additional set of 10 0.1 ha plots were established by R. Becking and J. Olson in 1977 on sites originally sampled by R. H. Whittaker in the 1960s. Despite the importance of long-term monitoring and research as a goal of the Biosphere Reserve Program, there is no current funding devoted specifically to the remeasurement of these plots.

The permanent plot system has been used to attract outside research (free to NPS): two studies of forest growth (Pyle and Callaway; these studies added soils data to the plots) and a study of organic fuels (Nicholas).

Rare, Endangered, and Threatened Species (RARE)

A research project on rare plant populations in GRSM was completed in 1982. This work included: review of previous work (principally by D. DeFoe, T. Howe, and S. P. Bratton), review of herbarium specimens at 10 herbaria, review of three heritage data bases (the Tennessee Valley Authority, Tennessee, North Carolina), and field surveys. Plants were prioritized and permanent population maps were created for the highest priority species. More extensive projects were carried out under Earthwatch funding on yellowwood, Rugel's ragwort, rare plants of grassy balds, and the effects of illegal gathering on orchid populations. Data on the park's rare and listed plants is more extensive than that contained in the state and federal (U.S. Fish and Wildlife Service) agency data bases and is a solid foundation for park needs. Due to the large size and complicated topography of the park, biological assessments will continue to require additional surveys for specific projects.

Road Corridor-Related Projects (ROADS)

Research related to road corridors consists of one project to date: an investigation of the yellow appearance of rhododendron in road cuts south of Newfound Gap. It was found that the yellow coloration was caused by soil chemistry and did not represent a pathological problem that would threaten the rest of the park's vegetation. (For projects describing environmental impacts of several road building projects, see EIS.)

Soils (SOILS)

GRSM lacks an up-to-date soils map. Earlier county soil surveys lacked detail on mountain soils. Recent efforts have included three projects on high elevation soils: a Soil Conservation Service (SCS) pilot project to map spruce-fir soils between Newfound Gap and Clingmans Dome (Sherril and McGowen), a dissertation on spruce-fir soils (Maguire), and an ongoing investigation of spruce-fir and hardwood soils (Lietzke). A fourth study is a National Acid Precipitation (NAPAP)-funded mapping effort addressing the sensitivity of watersheds to acidification. Several park watersheds are being mapped under this project.

Southern Pine Beetle (SOPINEBE)

The southern pine beetle is a native insect that periodically causes heavy mortality in yellow pine forests. This insect builds to high levels and is eventually controlled by occasional severe winter temperatures. The effect of beetle-caused mortality on these communities was studied by N. Kuykendall--the residual stand had increased importance of hardwoods and decreased importance of pine, due to the lack of disturbance to the forest floor (required for pine regeneration). Beetle-caused fuel accumulations were studied by Nicholas and White (see FIRE). These heavy fuel loads can result in fires hot enough to regenerate pine. Thus, there may be a beetle-fire-pine interaction that results in maintenance of this community in the landscape. The details of this possible interaction remain the focus for future research. The park has come under political pressure in the past to control this native insect during periods of widespread infestations. However, control methods are not compatible with allowing natural processes to occur (indeed, the southern pine beetle should be regarded as a protected species in GRSM, and its effect may be essential to pine regeneration) and, in any case, have not been successful in controlling the insect.

Special Protection Areas (SPECPROT)

Special protection areas have been described and floristic lists have been developed (see RARE and FLORA). A few special habitats have been sampled intensively for plant community structure (see PERMPLOT). Three areas have been fenced: a floodplain and a temporary pond in Cades Cove and a beech gap near Indian Gap. Permanent plots have been established in these areas in conjunction with the European wild hog exclosure project (see HOGS).

Vegetation Mapping (VEGMAP)

We currently lack a modern, park-wide vegetation map. The only map of the park's vegetation ever completed was the Miller Map of 1938, which was produced apparently without aerial photographs. A vegetation map is needed for prediction of fire behavior, wildlife studies, design of sampling strategies for a variety of issues, soils mapping, planning of park developments, and forecasting gypsy moth effects.

P. White and J. Rehder are currently involved in a major effort to produce a vegetation map from digital remote sensing data. Three resolutions are available for the park (80 m, 30 m, 13 m). Four other projects have used LANDSAT, 80-m resolution data: an attempt to interpret dark signatures on LANDSAT data (Ambrosia); interpretations of high elevation communities on Mt. LeConte, the Newfound Gap area, and Clingmans Dome (Olson and others); investigations of the ecotone between spruce-fir and hardwoods (DeSelm and others); and an early resource basic inventory project contracted to NASA (Su). None of these attempts has yet generated useful vegetation maps or data sets. Olson and Risser have recently been funded by NASA to address the feasibility for using 30-m resolution data for ecosystem analysis and 30-m resolution data from this project were made available for the overall park mapping project.

Other mapping efforts have included small area and single theme maps: for Mt. LeConte (Livingston and Mitchell), the intensive hog study area (Howe), Camels Hump and Huskey Branch stream monitoring watersheds (Harmon), the area of the proposed Blue Ridge Parkway extension (Baron), spruce-fir (Eagar; also Brown and others, listed under AIR-SARR), and high elevation non-forested communities (Stratton, White, and MacKenzie).

Visitor Impacts (VISIMP)

Visitor impact studies have included research on trail erosion, campsite impacts, firewood gathering impacts, and on the impacts of Mt. LeConte Lodge (by P. Whittaker, S. P. Bratton, and R. Nichols). P. R. Saunders studied recreation, logging, fire, and balsam wooly adelgid impacts to spruce-fir forests.

Bratton and co-workers found that trail erosion increased with elevation and was most severe in spruce-fir forests, grassy balds, and beech stands. Trail steepness was the most significant physical factor influencing amount of erosion. This study suggested that redistribution of visitor use will not reduce maintenance needs on the most susceptible trail sections (areas with high precipitation, steep trail slopes, and vulnerable vegetation types). Trail erosion patterns along the Appalachian Trail were recently reassessed by J. Renfro. This study supported the earlier findings in that trail impact was related to vegetation, precipitation (elevation), and trail slope; impact was also found to be correlated with soil type, especially at high elevations. Renfro's study noted that trail impact along the Appalachian Trail was less than one-tenth the damage reported for heavily impacted trails elsewhere, although the western data used for comparison were from extremely eroded sites and don't reflect average condition. In both studies, use restrictions were not seen as a mechanism of reducing damage or maintenance costs because of the relationship of damage to environmental factors. Shelter sites were found

by Bratton to have less intense visitor impacts per visitor night than campsite areas, although firewood gathering impacts (see PERMPLOT for the impact study by Stromberg, Harmon, and Bratton) and the amount of intensively disturbed area was proportional to the number of visitors at shelters, as it was at campsites. At 7,000 visitor nights, shelter sites are in poor condition, but replacing the high elevation shelters with campsites would cause more extensive impacts unless visitor use was also reduced. Renfro also found that shelter sites were in poor condition.

Campsite monitoring by the Ranger Division (R. Wightman) has shown that visitor use and impact have been decreasing in the backcountry, although these data have not been fully reported.

The consensus of the visitor impact studies is that, while acute threats to park resources are not occurring, continued monitoring is essential, given the high level of visitor use in the park. Design proscriptions to reduce impacts (i.e., increase carrying capacity) and to establish aesthetic guidelines are the subject of proposed research by J. Renfro and J. Peine (this program is being managed under the sociological studies program in the GRSM Science Division and will not be discussed here).

OUTLINE FOR FUTURE PLANT ECOLOGY RESEARCH IN GRSM

The fifteen research-related management objectives define a broad area of research interest. In this section, I will develop three themes to focus the plant ecology research program in Great Smoky Mountains National Park. I will then present an overview of the research prospectus (Table 10).

Research Themes

To understand human influences on park ecosystems (ranging from the current impacts of pollutant deposition and balsam woolly adelgid to the predicted effects of gypsy moth invasion and climatic warming), we must be able to describe the park's vegetation patterns and dynamics. Two of the three organizational themes for the plant ecology program will develop this understanding at the stand level (0.1-10 ha) and the landscape scale (100-10,000 ha). The processes of tree mortality, growth, and successional replacement must be studied on a plot scale; the pattern of these processes in space is important in such areas as wildlife studies, assessments of pollutant effects, and the effect of terrestrial ecosystems on aquatic ecosystems. Methods at these two scales are (1) permanent vegetation plots for long-term monitoring and intensive process-level studies at the stand level and (2) a geographic information system with remote sensing data for synthesis at the landscape scale (these methods are aimed at the description of park vegetation patterns across large areas--and thus an extensive system of non-permanent survey plots will be used).

The third organizational theme is the protection of biological diversity. Despite our best management efforts, sensitive species and gene pools will probably be threatened (e.g., by such highly specific pathogens as chestnut blight and balsam woolly adelgid). We must identify and monitor populations, assess genetic resources, and design strategies to maintain threatened gene pools that may disappear from the park under even the most optimistic scenario of increasingly effective management for protection from current threats.

Before describing in more detail these three themes, I must point out that a key to the success of any research strategy is the continuity of the research program and the development of strong research management. This is explicitly treated in the research prospectus described below: three of the prospectus titles need to be institutionalized (Develop Strong Research Management; Develop Long-Term and Holistic Studies; Participate in Monitoring Networks).

The stand level: vegetation dynamics. Sudden increases in tree mortality have been a key concern in studies of human impacts in the park. Tree mortality is also central to vegetation pattern and dynamics; it causes the release of regeneration during successional change, it controls the internal heterogeneity and patchiness of communities, and, because the tree stratum dominates total ecosystem biomass, it influences site environment and ecosystem processes.

Several management problems in the park were first recognized because of rapid increases in tree mortality. Research to determine forest state and trajectory has usually been initiated after the fact (e.g., in the case

of chestnut blight, southern pine beetle, fire effects, balsam woolly adelgid, and air pollution effects). Without planning, this situation is likely to recur (e.g., for gypsy moth establishment and potential climatic warming). Even in the case of acute threats, two to five year research projects have shown that forest mortality develops over a >5-20 year time span (chestnut blight, balsam woolly adelgid) and that predictions of future ecosystem state are subject to much uncertainty. Thus, short-term (<3-5 yr) answers are likely to be inadequate, particularly if no pre-impact data are available. Even if no new threats occur, and even if existing threats do not accelerate, evaluating vegetation change requires a long-term research strategy and the detailed information that permanent plots provide.

Past studies of the park's vegetation have produced little information on the natural turnover rates of canopy trees. The rate and pattern of mortality varies with site and history; threats to park resources are superimposed on this natural dynamics. Mortality patterns also influence community patchiness (both in terms of structure and composition); this patchiness has consequences for wildlife distribution, ecosystem processes, and disturbance propagation. The permanent reference plots used to develop an understanding of vegetation dynamics should also be used as the focus of ecosystem research (e.g., on such processes as litter and woody debris fall and decomposition, nutrient pools and transformations, and soil biology). The terrestrial research should be carried out on sites that will promote integration with aquatic and wildlife studies.

A permanent plot network is more important than threat-specific studies for several reasons. First, the existing threats to park resources are multiple. A study of fire effects in pine stands should be done in such a way that the plots will be useful for evaluating ozone symptomology of pines and for evaluating beetle-caused mortality. A second example is the suspected regional increase in mortality rate of old-growth oak stands. These kinds of stands are also susceptible to gypsy moth invasion. A permanent plot system should be established to address the overlapping concerns of these two issues. Further, we cannot fully predict the future management issues for which these plots will be useful; permanent plots will allow for an unlimited research potential over time and conclusions based on short-term data can be reevaluated periodically. A network of permanent plots forms the basis by which future threats can be evaluated (indeed, it is precisely the absence of such a network that prevents resolution of current issues, such as white pine and spruce mortality). Rather than spend more money to design a new sampling scheme for each future resource threat, it would be more cost effective to design a coherent forest research and monitoring strategy based on a well-established network of permanent plots. Threat-specific studies tend to concentrate on the minimum information required, while permanent plots will be used to characterized basic ecosystem structure and can be used to address multiple research and resource issues as they develop. They will also be useful in comparative studies based on the use of permanent plots elsewhere. Finally, research on specific threats (e.g., air quality degradation, expansion of European wild hog, elimination of fire, and invasion of exotic species) can and should be based around a permanent plot network. When this network is complete, more emphasis can be placed on specific threat-oriented research.

The landscape scale: vegetation patterns. GRSM possesses one of North America's most complex vegetation patterns. Diversity--of microclimate, vegetation, species, and gene pools--characterizes this landscape. Multi-spectral scanner data and digital terrain data will allow us to objectively map and model park ecosystems and their environments. Additional imagery can be acquired to detect changes in key ecosystems (e.g., in spruce-fir). Under the landscape theme, we should acquire and index historic aerial photography (historic aerial photographs will allow the assessment of changes caused by fire suppression and the detailed mapping of logging disturbance types). The overall goal should be the synthesis and modelling of landscape pattern, using a system capable of explicit spatial reference.

Biological diversity. Within the temperate zone, only the East Asian flora is more diverse than that of the southern Appalachians. Great Smoky Mountains National Park ranks at or near the top of all national parks in floristic diversity, despite the fact that it ranks below the top ten in size. Among the park's 1500 vascular plant species are three strict endemics, as well as a number of other regional endemics for which GRSM protects key populations. The high mountains support many northern species, including disjunct species and species at their southern range limits. High elevation cliffs support a flora that is the remnant of a southern Appalachian alpine zone (last important in the south ca. 12,000 years before present). The large size, wide environmental gradients, and undisturbed history of the park means that genetic diversity is high in many populations. Despite the park's legal protection, highly specific threats to particular gene pools have occurred and have exceeded our ability to protect wilderness ecosystems (e.g., balsam woolly adelgid and chestnut blight).

Because GRSM has been the site of significant research for over 50 years (and because its biological diversity has attracted the attention of specialists), the park is in the unique position of having relatively complete checklists for nearly all plant groups and fungi. GRSM is in a position to become the first National Park Service biosphere reserve and U.S. national park to produce a computer-indexed catalogue of species for vascular plants (already nearly complete), bryophytes, lichens, and fungi. This effort should include important ecological (e.g., elevational distribution, abundance) and management (e.g., pollution sensitivities) information. A computerized catalogue would demonstrate the biological richness of the area and the importance of resource inventory and baseline information for biosphere reserves.

Plant Ecology Research Prospectus

Table 10 presents the research prospectus. In this table, individual project titles are listed within the 15 research-related management goals. Some research task fit more than one management goal. The overlap is most apparent for the three central tasks (goals 1, 2, and 9 in Table 10). The first two goals (Inventory resources; Understand landscape and ecosystem structure, function, and dynamics) contain much of the landscape- and stand-level research described above. Other aspects of this focus are contained in 11 (Develop strong research management) and 12 (Develop long-term and holistic studies). The biological diversity theme is contained in

Table 10. A plant ecology research prospectus for Great Smoky Mountains National Park, arranged by research-related management goals (*=top priority titles; +=ongoing projects). The categories are interrelated, especially for categories 2, 5, 6, 11, and 12, for categories 5 and 14, and for categories 8, 9, and 15. See text for details of program organization.

Research-related management goals and research topics

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1 Inventory resources

+*1.1 Complete remote sensing based vegetation map and data base
+*1.1.1 Complete analysis of evergreen vegetation
+*1.1.1.1 Complete analysis of spruce-fir vegetation
+1.1.1.2 Complete analysis of heath bald distribution
+*1.1.2 Complete analysis of deciduous vegetation
1.1.3 Acquire additional remote sensing data for monitoring
+*1.2 Complete geographic information system
1.2.1 Complete entry of available themes
1.2.2 Model site environment from digital terrain data
1.3 Inventory, map, and complete management overview for important resource types
1.3.1 Wetlands
1.3.2 Sinkholes
1.3.3 Stream gorges
1.3.4 Rock outcrops
1.3.5 Old-growth stands and record trees
1.3.6 Large spring wildflower display areas
1.4 Complete soils map
1.4.1 Design specifications for soils map
1.4.2 Carry out mapping project
1.5 Complete geologic map
1.6 Refine disturbance history work with field and remote sensing data
1.7 Complete computerized organism checklists
1.7.1 Complete and computerize checklists for bryophytes, lichens, and fungi
+1.7.2 Complete vascular plant data base

2 Understand ecosystem and landscape structure, function, and dynamics

*2.1 Complete permanent plot network
*2.1.1 Design sampling strategy
*2.1.2 Establish 0.1-1.0 ha reference plots
+2.1.3 Complete synthesis of past vegetation data sets
*2.2 Build data base on key ecosystem parameters
2.2.1 Biomass, productivity, nutrient pools, transformations
2.2.2 Litter fall, woody debris, and decomposition rate
*2.3 Survey disturbance patch structure
*2.4 Model landscape distribution of vegetation, based on remote sensing and geographic information system
2.5 Model ecosystem dynamics and processes
+2.5.1 Complete adaptation of FORET
2.5.2 Test model predictions for disturbances

Table 10, continued

2.6 Summarize and model environment
2.6.1 Model frequency of intense rain storms, flood scour, and flood regime
2.6.2 Understand debris avalanche frequency
2.6.3 Review and summarize weather records
2.7 Upgrade mast survey program
2.8 Design and carry out a periodic survey of major, stand altering, pests and pathogens
2.9 Establish photo-monitoring program

3 Minimize visitor impacts

+3.1 Continue review of monitoring program
3.2 Monitor Mt. LeConte visitor impacts
3.3 Determine streamside impacts at popular rafting and swimming areas

4 Minimize exotic species impacts

+*4.1 Understand the impact of the European wild hog
+*4.1.1 Continue exclosure project
4.1.2 Assess impact of wild hogs on tree regeneration
4.1.3 Expand impact study to other understory types
4.1.4 Assess impact of hogs on vernal flower displays
+4.1.5 Complete design of hog rooting index
4.2 Understand gypsy moth impacts and construct management plan
4.2.1 Establish study areas for pre-invasion measurements
4.2.2 Complete susceptibility/vulnerability analysis
4.2.3 Assess potential impact on rare species
4.2.4 Develop cooperative research with other NPS sites
4.3 Minimize the impacts of exotic plants
+4.3.1 Complete the survey of developed areas
4.3.2 Develop management plan for Japanese honeysuckle
4.3.3 Assess impacts of Japanese grass
4.3.4 Monitor top priority exotic species populations
4.4 Develop a site specific list of native plants for developed areas

5 Understand and minimize the effects of atmospheric deposition

+*5.1 Perform open-topped chamber studies
+*5.2 Continue spruce-fir ecosystem assessment
+*5.3 Continue research on ecosystem processes in spruce-fir
5.4 Establish a project on pre-visual strees in forest trees
+*5.5 Complete assessment of pollutant sensitivities of rare plants
+*5.6 Continue assessment of symptomology in white pine
*5.7 Carry out survey of hemlock condition and mortality
5.8 Carry out survey of yellow pine condition and mortality
+*5.9 Complete soils map for watershed survey
*5.10 Establish lichen baseline data
+*5.11 Complete analysis of tree decline surveys

Table 10, continued

6 Restore natural processes

- 6.1 Reestablish fire as an ecological factor
  - 6.1.1 Convert volumentric fuels data to mass
  - 6.1.2 Model fuel mosture as a function of site and weather
  - *6.1.3 Understand fire behavior and effects
  - 6.1.4 Refine management response to fire
  - 6.1.5 Understand landscape trajectory of pine stands
  - 6.1.6 Model the fire-pine-beetle-drought interaction
  - *6.1.7 Understand fire risk in spruce-fir
  - 6.1.8 Expand fire history field work
  - 6.1.9 Understand effects of fire suppression
- 6.2 Rehabilitate lands effected by logging and severe slash fires
  - 6.2.1 Understand mechanisms of heath bald dominance
  - 6.2.2 Reestablish forest succession in grape thickets
  - 6.2.3 Survey cable logged areas and sites of severe erosion

7 Protect unique areas

- *7.1 Monitor Special Protection Areas
  - *7.1.1 Seepage area on Andrews Bald
  - *7.1.2 Cliff Tops
  - *7.1.3 Gum Swamp and Lower Abrams Creek floodplain
- *7.2 Protect a mid-elevation old-growth site with well-developed spring flora
- +7.3 Continue restoration of Grassy Balds
  - +7.3.1 Complete grassy balds flora
  - +7.3.2 Assess management
  - 7.3.3 Reestablish Helianthemum bicknelii

8 Protect rare species

- *8.1 Complete rare species maps and summary report
- *8.2 Write management plan for top priority species
- *8.3 Reintroduce extirpated species
- *8.4 Monitor top priority species

9 Protect genetic diversity

- *9.1 Complete a Fraser fir gene pool management plan
  - *9.1.1 Assess genetic resistance of Mt. Rogers gene pool
  - *9.1.2 Predict extinction risk for Fraser fir
  - *9.1.3 Establish program to maintain Fraser fir gene pool
- *9.2 Complete an American chestnut gene pool management plan
- 9.3 Complete a grassy bald azalea gene pool management plan

Table 10, continued

10 Prevent adverse impacts of park management

10.1 Perform biological and environmental assessments

11 Develop strong research management

11.1 Index aerial photography and acquire additional sets
+11.2 Index maps
+11.3 Establish bibliographic system
+*11.4 Complete data management proscription
+11.5 Continue project register data base
11.6 Design annual report on major science research findings
+11.7 Continue bibliographic series
*11.8 Develop data archiving plan
+*11.9 Complete curation of past permanent plot data
11.10 Review research program at a minimum of 10 yr intervals
11.11 Establish a computerized data base of natural history observations

12 Develop long-term and holistic studies (see 2, 5, 11)

*12.1 Integrate plant ecology with wildlife and aquatic programs
12.2 Establish process for integrating and reporting research results
*12.3 Carry out annual sampling on reference plots
12.4 Design a specimen banking program

13 Participate in comparative research (see 5)

*13.1 Establish collaborative projects with Coweeta Hydrologic Lab
*13.2 Develop multi-park projects on air quality, gypsy moth, wild hog
*13.3 Continue strong role in Spruce-fir Cooperative
*13.4 Participate in regional grassy balds management program
13.5 Establish collaborative projects on protection of temperate forest diversity in East Asia
13.6 Continue international biological diversity project
13.7 Establish project with European site on air quality impacts

14 Participate in monitoring networks (see 5)

*14.1 Continue and strengthen interaction with NAPAP
*14.2 Continue participation in national NPS Air Quality Program
*14.3 Establish regional monitoring of European wild hog impacts
*14.4 Continue involvement in gypsy moth monitoring
*14.5 Establish regional monitoring of old-growth stands

15 Carry out research in conservation biology (see 9)

15.1 Develop regional plan on the conservation of floristic diversity
15.2 Establish collaborative projects winter habitat for avifauna
15.3 Understand the impacts of traditional gathering of wild ramps
15.4 Establish ecologically sound right-of-way and vista management

goals 8 (Protect rare species), 9 (Protect genetic diversity), and 15 (Carry out research in conservation biology).

The list of projects is long. It is not intended to be solely implemented by the park's research staff. Some of the projects (particularly biological assessments and monitoring) have been carried out by the Resources Management staff. More importantly, the outside research interest in the park can be better focused on the park's research needs. With over 150 separate projects carried out in the park each year with no direct connection to park research programs, this coordination becomes an important issue. The park also has the opportunity to maintain its good record of attracting outside research support. Many resource issues of interest to the National Park Service are also of interest to TVA, the Forest Service, Oak Ridge National Laboratory, and the private sector; some of these are already resulting in projects funded with non-Park Service funds (e.g., the SARRMC spruce-fir assessment). The permanent plot scheme should be used to attract and focus this outside research interest.

The following pages discuss only the highlights of the prospectus, with special emphasis on the three research themes discussed above. Table 10 presents a full list of project titles; top priority projects are indicated by an asterisk (*).

Inventory Resources

Despite the world renown forest diversity of the park, there is no contemporary all-park vegetation map (the only such map was completed in the 1930s). A vegetation map has applications in a variety of management areas: forest fuel models, fire behavior, ecosystem change (including loss of pine dominance with fire suppression), potential impacts of the exotic gypsy moth, alteration of spruce-fir forests due to balsam woolly adelgid and possible air pollution effects), habitat use by wildlife (including European wild hog damage to high elevation beech forests and calculation of hard and soft mast production), and better understanding of the effect of terrestrial ecosystems on aquatic systems. The central task here is the completion of a quantitative vegetation map based on multi-spectral scanner data and a geographic information system containing data on terrain, soils, geology, and disturbance history. At present, the park lacks a modern and comprehensive soils map. A completed vegetation map and geographic information system will allow the more efficient production of a such a map. The park's geologic base maps also need to be reviewed and extended to unmapped sections of the park.

Several kinds of geologic formations, site types, and plant communities should be the subject of special inventories. The general location of old-growth stands is well-known in the park, but particular big tree areas have not been mapped or assessed. An inventory and map of the park's state and national record trees should be embedded within a general field survey of the park's old-growth resources. It is very likely that additional stands containing record trees will be discovered.

Because of past research on the park's floristic diversity, we are in a unique position to produce a computerized information system of all the terrestrial plant taxonomic groups: vascular plants (nearly complete), bryophytes, lichens, and fungi.

Understand ecosystem and landscape structure, function, and dynamics

The central task here is the completion of a network of permanent plots and the use of the geographic information system to model vegetation and environment in the landscape. This effort should include an examination of the empirical relations between environment and topography and analysis of historic weather records (this might result in the design of a better scheme for collecting weather data in the park). The reference plots themselves should be used as the basis for studies involving animal populations, soil biology, aquatic systems, cryptogams, pathogens, and ecosystem processes. Past vegetation data sets should be assembled and archived; some of these may hold promise for inclusion within the reference plot system. The permanent plots should be surveyed annually for canopy tree mortality, exotic species impacts, large animal effects (deer browse, small mammals, black bears), seed rain (including an upgrade of the park's hard mast data base), and litter and woody debris fall. Permanent plots should form the focus of ecosystem process research, should be used to attract and organize outside research interest, and should be used to focus the integration of aquatic and animal studies with vegetation research. With the recent establishment of permanent plots in the park's spruce-fir forest, the key need is in the park's old-growth cove hardwood, hemlock-hardwood, and mixed oak stands. We are not now in a position to fully characterize change in these stands.

Past vegetation studies have emphasized patches of mature vegetation. This creates a bias, in that sample plots tend to have higher basal areas than actually occur within a community and long-term monitoring is carried out on one structural state (patches of old trees) of the community. The permanent plot scheme must be designed to sample the natural heterogeneity and patchiness of stands and to ensure that we can monitor all structural and age patches. The structure, composition, and age of patches influences their response to human influences and the distribution of wildlife. Despite the scientific and aesthetic value of the park's old-growth forests, we do not possess an understanding of their overall trajectory. A key question is whether these stands can be described as essentially in dynamic equilibrium, or whether their size and patchiness would foretell a directional loss of massive tree structure. We also need a better understanding of patchiness in old-growth stands and the relation of vertebrates, invertebrates, and cryptogams to this natural patchiness.

These stands are important for understanding the behavior of unmanaged forests and for baseline information on southern Appalachian ecosystems. Study of these stands will allow us to better understand logging impacts and to give a fuller context to conclusions drawn from the National Science Foundation-sponsored Long-term Ecological Research site at Coweeta Hydrologic Laboratory, where all stands had been disturbed when the research station was established.

In addition, better understanding of several broad-scale processes in the park's landscape is needed. The most important of these are fire behavior and the interaction of fire and southern pine beetle in pine-dominated forests and post-logging succession (see "Restore natural processes" below), pest and pathogen effects, flood regime, and climate. We need a formalized and periodic assessment of the major stand-influencing pests and pathogens, including both native and exotic species. This could

be done in cooperation with the Forest Service and other outside scientists. Rare, intense rainfall events lead to debris avalanches at high elevations and to flash flooding at lower elevations. These events lead to changes in aquatic, floodplain, and streamside communities. Although the effects of these floods are evident on aerial photographs, they have not been studied. Important factors are recurrence interval and magnitude, along with an understanding of mechanisms (e.g., of debris avalanches), effects on stream communities (including the effects of natural exposure of Anakeesta), and succession. This area is politically important because tourist development is concentrated on or near floodplains beyond park boundaries; this represents an important interface between the park and its surroundings.

Because human caused threats overlay natural sources of ecosystem change, the influence of several potential sources of change must be better understood. Foremost among these is climatic variation, in particular periodic severe drought (important in the interpretation of tree growth rates, susceptibility to insect attacks, and fire intensity), intense rainfall events (important in triggering debris avalanches and flooding), and early and late damaging frosts (implicated in one air pollution effects hypothesis). Although this summary would be specific to the few sites where data have been collected, a broad understanding of the frequency and intensity of events could be obtained from the statistical modelling of TVA weather records, in conjunction with a wider literature review. An annual weather summary for the park could then be designed and the park's weather data collection scheme could be improved (the issue of climatic warming due to increased atmospheric carbon dixoide must be evaluated in the park). Since it will never be possible to instrument a large and heterogeneous landscape like GRSM, digital terrain-based modelling must be applied to the problem of extrapolation from existing data and a relatively low number of weather stations.

Finally, permanent photo points, some of which should be based on historic photographs, should be established; a variety of scales is important, from lichen photomonitoring (one square meter) to the monitoring of human impacts (vegetation and rare species impacts at Clifftops, ca. 100 square meters) and landscape vistas of ecosystem pattern (several square kilometers).

Minimize Visitor Impacts

Clifftops on Mt. LeConte is a popular hiking destination and the most important rare plant site in the park. Historic photographs and current field studies have revealed a pattern of severe vegetation loss from the summit. Continued erosion of plant cover should be assessed and methods for further protection should be developed.

Minimize Exotic Species Impacts

The key task here is to document the impact of European wild hog, the potential for vegetation recovery after hog exclusion, and trends in the extent of damage across the park. The hog exclosures should be sampled twice a year for five years; the project should then be reassessed. We

need better information on hog impacts in high elevation springs and seepage areas. Spring flower displays are a popular aesthetic resource--rich mid-elevation stands should be assessed for hog impacts on such flowering displays. The wild hog has the potential to become established throughout the southern Appalachians. The monitoring of damage caused by hogs, especially tree regeneration and water quality, can and should be done in cooperation with other regional land management agencies. We must examine influences on aesthetics, rare and endangered populations, mast availability for other wildlife species, and forest regeneration patterns.

The gypsy moth will likely infest the region within the next 5 to 20 years. There will be effects on tree mortality, forest productivity, native lepidopterans, bird and small mammal populations, litter fall, mast production, and aesthetics (including landscape effects and more local and direct effects in campgrounds and picnic areas). Alternative management strategies need to be evaluated before the problem becomes acute. We should develop close communication with the gypsy moth research community.

Understand and Minimize the Effects of Atmospheric Deposition

Establishing the causes and effects of ambient levels of criteria air pollutants and developing the ability to forecast the effects of increased levels of pollutants are central to this program element. For some pollutants, field fumigations using open-topped chamber experiments would be an appropriate approach. This work will bring a new level of sophistication in park air quality impact studies (it will provide a better match for the deposition and visibility monitoring in the park) and will result in more usable data under the Clean Air Act. Field work should be designed to complement this experimental work. The park should maintain its position as a primary research site for air pollution-related research through the facilitation of research from outside institutions.

Restore Natural Processes

Fire management and past logging impacts are the central themes here. Fire suppression is currently practiced in the park. While the recent fire history is well-known, park management needs a better ability to predict fire behavior and a better understanding of the natural role of fire. Understanding the natural fire regime has been made complicated by over 150 years of frequent human-set fires (particularly important in western GRSM) and its nature can probably only be estimated by modelling studies. Past interest in management fire has been often tied to the issue of regeneration of pine stands; however, we do not yet have adequate knowledge of the rate of landscape loss of pine dominance.

Southern pine beetle periodically causes widespread mortality in yellow pines, thus altering fuel levels and increasing the potential for high intensity fire. In the past, the park has come under pressure to control the insect, but has more recently resisted this pressure (in any case, the infestations are best controlled by periodic severe winter cold). There could conceivably be an interaction of atmospheric deposition and vulnerabilty to beetles. The reproduction of a southern Appalachian endemic tree, table mountain pine, is probably dependent on fires of high intensity; such fires may occur only in drought years and in stands with high levels of woody fuels (e.g., after southern pine beetle outbreak).

The park must develop a full understanding of the possible synergism between fire, beetle infestation, and drought. Fire effects on many taxonomic groups have not been evaluated.

Fire risk in spruce-fir forests must be assessed because of the heavy fuel loads created by balsam woolly adelgid infestation. As with fire behavior studies for other ecosystems, fuel mass and fuel moisture data are essential--since this ecosystem occurs in a humid environment, catastrophic fire is potentially important only after severe drought.

Logging and its associated by-product, slash fire, have initiated succession over large areas of the park's landscape. Some of the severely disturbed sites have not fully recovered after 60 years of protection. In some cases this is due to severe soil erosion, but in other cases the mechanism may include biological factors (e.g., grape thickets and logging-produced heath balds).

Protect Unique Areas

Monitoring of Special Protection Areas and grassy balds are the central tasks here. A rich mid-elevation old-growth stand with rich spring flowering display should be added to the Special Protection Area system.

Protect Rare Species

All proposed and listed state and national rare and endangered species in GRSM have been assessed in the park, with permanent population plots established for several top priority species. More specific plans should be written for the park's endemic species. To facilitate biological assessments, all significant rare species should be mapped on a standard reference set of park quadrangle maps. Field surveys of the sites of proposed development will continue to be required. Reintroduction of several extirpated species (e.g., Helianthemum on Gregory Bald) should be initiated after grassy balds restoration is complete.

Protect Genetic Diversity

The central tasks here are the writing of gene pool rescue plans for Fraser fir, American chestnut, and azalea hybrids. Fraser fir populations on Mt. Rogers are a possible source of resistance to the balsam woolly adelgid; in the meantime, a plan for the collection and storage of genetic diversity in Fraser fir should be designed.

Prevent Adverse Impacts of Park Management

Research should continue to support biological and environmental assessments on future park developments, such as roads, vista clearings, trails, and picnic areas.

Develop Strong Research Management

The establishment of a long-term perspective and a permanent plot network in reference areas requires a strong effort in data management to ensure data survival. This strategy should include quality control procedures for data collection and entry, adequate archiving of data sets,

and an explicit plan for reinventory and marking of plots.

Develop Long-Term and Holistic Studies

Most of the long-term strategy is contained in elements two and eleven. Here should be stressed the continuing nature of measurements on reference plots, and the inclusion of studies on cryptogams, soil biology, ecosystem processes, animal populations, and the integration of terrestrial with aquatic research plans.

Participate in Comparative Research

The top priority here is to develop a comparative research project with Coweeta Hydrologic Laboratory, based on the question of successional age and ecosystem processes, in order to benefit from and more fully understand the results being obtained at the Coweeta Long-term Ecological Research site. Also included here are projects on common issues with Shenandoah, Cumberland Gap, Mammoth Cave, Blue Ridge Parkway, and Acadia National Parks. GRSM should maintain its role in the SARRMC spruce-fir ecosystem assessment and in regional management of grassy balds.

An opportunity exists for comparative research at the international level in several areas: on air pollution effects in coniferous forests with European sites, temperate forest diversity with East Asian sites, and design of information systems for the storage of data on biological diversity with other international biosphere reserves under the MAB program.

Participate in Monitoring Networks

GRSM should maintain its air quality and gypsy moth monitoring. The park should work more closely with other regional Class I airsheds in impact assessment. A monitoring network should be developed for impacts of the European wild hog. The park should lead the establishment of a monitoring scheme for regional old-growth forests.

Carry Out Research in Conservation Biology

Research should establish the feasibility of writing a multi-participant plan for the protection of southern Appalachian floristic diversity. The impact of traditional gathering of ramps on park populations, as well as the larger issue of these kinds of impacts on other species, represents an area for future research with particular importance to temperate forest conservation in East Asia. Improved management of powerline right-of-ways, roadsides, and vistas can be based on research to establish stable shrub communities in these areas. On right-of-ways this would reduce the need for herbicides and, in other areas, would reduce the cost of management.

CONCLUSIONS

This report has produced the first overview of terrestrial plant ecology in GRSM since 1976. I conclude the following:

1. The research mandate of the National Park Service and Great Smoky Mountains National Park is contained in broad, but powerful, statements that describe the purpose of the national parks. This broad mandate has been augmented by a number of more specific legal requirements (the Clean Air Act, the Endangered Species Act, the Wilderness Act) and by voluntary cooperative agreements represented by the Man and the Biosphere Program and the World Heritage Convention. Further, these principles have been used to construct the GRSM Statement for Management and the Resource Management Plan. The time has come to implement the vision contained in these documents.

2. The research program in the National Park Service and GRSM is young; a more mature phase is now required.

3. There has been an impressive amount of research carried out in GRSM, both by National Park Service-sponsored science programs and by outside reseachers. An overview of 345 projects carried out since 1972 is presented under 37 major headings. Projects that have directly involved National Park Service personnel number 151.

4. A network of well-designed permanent plots should be implemented, with a geographic information system (using remote sensing data, digital terrain maps, and other information) to give spatial context to intensive stand-level studies.

5. Research projects in the research prospectus are organized under fifteen research-related management objectives. Key elements of the research prospectus include: development of the geographic information system; establishment of permanent plot network; detailed inventory of old growth hardwood and hemlock-hardwood forests, with establishment of intensive reference plots in these stands; comparative research based on Coweeta Long-Term Ecological Research site studies; comparative research with other regional Class I airsheds; direct experimentation on the effects of ambient levels of criteria air pollutants; experimental study of fire behavior and effects; completion of studies of impacts of the European wild hog; development of plans for preservation of genetic diversity of key threatened gene pools; and development of strong research management.

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APPENDIX I

PLANT ECOLOGY RESEARCH

IN GREAT SMOKY MOUNTAINS NATIONAL PARK

AND BIOSPHERE RESERVE

A PROJECT REGISTER

This register of plant ecology projects was completed from the files of the author and from the Annual Investigator Reports, Collecting Permit Applications, and Resource Activity Permit Applications of the Resource Management Division office in Great Smoky Mountains National Park. All plant ecology-related projects carried out since 1972 were included. The projects are arranged by broad category (PROJREG of the data base file). For definitions of these categories (and, hence, of the scope of the included research), see page I-2 of this Appendix. I have included several monitoring projects carried out by the Resource Management and Ranger Divisions of the park.

The register presented in this Appendix is based on a data base developed using dBASEIII software. The complete structure of this data base is presented on page I-3 of this Appendix, but a few of the categories do not appear in the printed list of projects. The excluded categories are: PPIS (past principal investigators, which applies only to a few projects); FUNDING (which is unknown for many projects unrelated to NPS management); KEYWORD (used in generating indexes); GENERAL (which is a variable to flag integrative projects that are based on a number of separate projects, which do not generate specific data sets and the like); and OUT (used to flag projects carried on outside GRSM). DATEBEG (beginning date) and DATEEND (ending date) are collapsed together on the printout as "YEAR". Citations can be found in Appendix II.

The data base structure is shown on page I-3. Projects are arranged alphabetically by category (PROJREG of data base structure) and then alphabetically by principal investigators (PIs). The PROJREG categories are described on page I-2 of this Appendix. It is obvious that no classification of projects will be entirely satisfactory. For example, basic research on plant community structure falls under AIR-SARR (SARRMC spruce-fir ecosystem assessment program), AIR-VEGC (vegetation effects of air quality at the community level), and GRASSYB (grassy balds projects). Studies of the genetic diversity of azaleas have been placed under GENDIVER (genetic diversity projects), although they are related directly to three other categories: FLORA (vascular plant floristics), GRASSYB (grassy balds projects), and RARE (rare species). I have therefore provided a cross reference system for each project.

PROJREG (project register) categories. The first seven categories (all prefaced by "AIR-") are equivalent to those used on the Air Quality Project Register (White et al. 1985).

ABBREVIATION	COMMENTS
AIR-ECOS	Air quality related ecosystem level projects
AIR-LICH	Air quality related research on lichens
AIR-SARR	SARRMC spruce-fir ecosystem assessment program
AIR-TRAC	Air quality related studies on trace elements
AIR-VEGC	Air quality effects on plant communities
AIR-VEGP	Air quality effects at the physiological level
AIR-VEGT	Air quality projects related to tree or forest decline
BIBLIOG	Bibliographies
BIGTREE	Record sized trees
BRYOPHYT	Bryophyte ecology and systematics
BWA	Balsam woolly adelgid
CHESTNUT	American chestnut and chestnut blight
DISTHIST	Disturbance history
ECOSYST	Ecosystem level projects
EIS	Environmental assessments
ETHNOBOT	Ethnobotany
EXPLANTS	Exotic plants
FIRE	Fire history and ecology
FLORA	Vascular plant floristics and systematics
FUNGI	Systmatics and ecology of fungi
GAPS	Forest gap phase dynamics
GENDIVER	Genetic diversity related studies
GENERAL	General
GENVEG-A	General vegetation-autecological studies
GENVEG-C	General vegetation-community studies
GIS	Geographic information systems
GRASSYB	Grassy balds
GYPSY	Gypys moth
HOGS	European wild hog
ISLANDS	Island biogeography
LANDSL	Debris avalanche and landslide studies
LICHENS	Lichen ecology and systematics
MODEL	Simulation modelling
PALEO	Paleoecology
PATHOL	Plant pathology
PERMPLOT	Permanent vegetation plots
RARE	Rare, endangered, and threatened species
ROADS	Road corridor related projects
SOILS	Soils
SOPINEBE	Southern pine beetle
SPECPROT	Special protection areas
VEGMAP	Vegetation mapping
VISIMP	Visitor impact

DATE BASE STRUCTURE: PROJREG.DBF

Field Name	Type	Width	Comments
PIS	C	67	Principal investigator(s)
*PPIS	C	40	Past PIs (due to staff turnover)
TITLE	C	135	Title of project
DATEBEG	C	4	Year beginning
DATEEND	C	4	Year ending
STATUS	C	4	Status: (blank)--uncertain ONG--ongoing COMP--completed PREP--report in preparation REV--report in review ABAN--abandoned
INST	C	35	Institution
*FUNDING	C	10	Funding institution
*KEYWORD	C	67	Keywords
PROJREG	C	8	Project register category
CROSSREF	C	50	Cross references to other PROJREG categories
*GENERAL	C	1	General integrative projects: (blank)--No 1--Yes
LEVEL	C	30	Ecological level(s) of project: LANDSCAPE, ECOSYSTEM, COMMUNITY, POPULATION, PHYSIOLOGICAL, CHECKLIST, GENERAL
RMP	C	8	Statement number from Resources Management Plan (1985): One or two digit number only--general RMP title Number plus additional digits and letter--specific reference to a project statement BDATA--base line data only
NOTRMP	C	1	Not specifically listed in Resources Management Plan (RMP): (blank)--Specifically listed in RMP 1--Older projects done under previous RMP and projects that clearly relate to 1985 Plan, though not specifically listed in that document 2--Not directly relating to RMP
GRSMSCI	C	1	Projects carried out with funding, resources and/or personnel from GRSM Science Division (blank)--no 1--Yes
*OUT	C	1	Projects carried out outside GRSM (blank)--no 1--Yes
CITATIONS	C	100	Citations to completed publications and reports

*Not included on the printed list of projects which starts on the next page.

PROJREG AIR-ECOS RMP 01.4.C.1 GRSMSCI 1
PIs Johnson, D. W., and S. E. Lindberg
TITLE Effects of atmospheric deposition on canopy and soil processes and on elemental cycling
YEAR 1985-1988 STATUS ONG
INST ORNL
CROSSREF AIR-VEGC,AIR-SARR,ECOSYST,SPRFIR LEVEL ECOSYSTEM
CITATIONS

PROJREG AIR-ECOS RMP 01 NOTRMP 1 GRSMSCI 1
PIs Jones, H. C., J. M. Kelly, H. Olem, and J. C. Noggle
TITLE TVA Raven Fork study
YEAR 1983- STATUS ONG
INST TVA
CROSSREF AIR-VEGC,AIR-ECOS,ECOSYST,SPRFIR LEVEL ECOSYSTEM
CITATIONS Jones et al. 1983

PROJREG AIR-ECOS RMP 01.4.C.1 GRSMSCI 1
PIs Stam, A.
TITLE Effects of simulated acid precipitation on aluminum in soil solutions of the spruce-fir forest
YEAR 1984- STATUS ONG
INST ORNL
CROSSREF AIR-VEGC,SPRFIR,ECOSYST,AIR-TRAC LEVEL ECOSYSTEM
CITATIONS

PROJREG AIR-LICH RMP 01.4.C.1 GRSMSCI 1
PIs DePriest, P.
TITLE A lichen and bryophyte ecological baseline study in spruce-fir
YEAR 1984-1986 STATUS PREP
INST Northrup
CROSSREF SPRFIR,BWA,GENVEG,AIR-SARR LEVEL COMMUNITY
CITATIONS

PROJREG AIR-LICH RMP 01.4.C.3 GRSMSCI 1
PIs DePriest, P., J. Bennett, and L. Gough
TITLE Mapping elemental concentrations with lichens
YEAR 1983-1986 STATUS PREP
INST Northrup,NPS-Air,USGS
CROSSREF AIR-VEGP,AIR-VEGC LEVEL PHYSIOLICAL,ENVIRONMENTAL
CITATIONS

PROJREG AIR-LICH RMP 01 NOTRMP 1 GRSMSCI 1
PIs Sigal, L. L.
TITLE Acid rain and gaseous pollutant effects on lichens
YEAR 1982-1983 STATUS COMP
INST ORNL
CROSSREF AIR-VEGC,AIR-VEGP LEVEL COMMUNITY
CITATIONS

PROJREG AIR-LICH RMP 01 NOTRMP 1 GRSMSCI 1
PIs Wetmore, C. M.
TITLE Lichens of the Air Quality Class I National Parks
YEAR 1982-1983 STATUS COMP
INST UMinnesota
CROSSREF FLORA,AIR-VEGC,AIR-VEGP LEVEL CHECKLIST,POPULATION
CITATIONS Wetmore 1983

PROJREG AIR-SARR RMP 01.4.C.1 GRSMSCI 1
PIs Binkley, D., and C. Wells
TITLE Nitrogen transformations in spruce-fir soils
YEAR 1985- STATUS ONG
INST Duke,NC State
CROSSREF SPRFIR,ECOSYST,AIR-ECOS LEVEL ECOSYSTEM
CITATIONS

PROJREG AIR-SARR RMP 01.4.C.1 GRSMSCI 1
PIs Brown, D., C. Dull, and B. Shain
TITLE Aerial survey of southern Appalachian spruce-fir
YEAR 1985- STATUS ONG
INST USFS-Forest Pest Management,Clemson
CROSSREF AIR-VEGC,VEGMAP,BWA,SPRFIR LEVEL LANDSCAPE,VEGETATION MAP
CITATIONS

PROJREG AIR-SARR RMP 01.4.C.1 GRSMSCI 1
PIs Bruck, R., and F. Hain
TITLE Evaluation of the incidence of mycorrhizae, pathogens, and insect pests
YEAR 1985- STATUS ONG
INST NCSU
CROSSREF AIR-VEGC,AIR-VEGP,BWA,SPRFIR LEVEL POPULATION,PLANT PATHOLOGY
CITATIONS

PROJREG AIR-SARR RMP 01.4.C.1 GRSMSCI 1
PIs Eagar, C., P. S. White, S. M. Zedaker, N. S. Nicholas, and T. Burke
TITLE Spruce-fir ecosystem assessment: site characterization
YEAR 1984- STATUS ONG
INST NPS-UPL,NPS-CPSU,SARRMC
CROSSREF PERMPLOT,AIR-VEGC,AIR-VEGP,SPRFIR LEVEL COMMUNITY
CITATIONS

PROJREG AIR-SARR RMP 01.4.C.1 GRSMSCI 1
PIs Maguire, L.
TITLE Forest modelling in southern Appalachian spruce-fir
YEAR 1985- STATUS ONG
INST Duke
CROSSREF MODEL,GENVEG,AIR-VEGC,SPRFIR LEVEL COMMUNITY,ECOSYSTEM
CITATIONS

PROJREG AIR-SARR RMP 01.4.C.1 GRSMSCI 1
PIs Ragsdale, L.
TITLE Dendrochronological validation and stem analysis in southern Appalachian spruce-fir
YEAR 1985- STATUS ONG
INST Emory
CROSSREF GENVEG,AIR-VEGC,AIR-VEGP,SPRFIR LEVEL POPULATION
CITATIONS

PROJREG AIR-SARR RMP 01.4.C.1 GRSMSCI 1
PIs Wells, C., and W. Robarge
TITLE Soil and plant tissue analysis in southern Appalachian spruce-fir
YEAR 1985- STATUS ONG
INST USFS,NCSU
CROSSREF AIR-VEGP,AIR-TRAC,SPRFIR LEVEL ENVIRONMENTAL,PHYSIOLOGICAL

PROJREG AIR-SARR RMP 01.4.C.1 GRSMSCI 1
PIs Wentworth, T., and P. S. White
TITLE Historical data base and land-use compilation in southern Appalachian spruce-fir
YEAR 1985- STATUS ONG
INST NCSU,NPS-CPSU-Tennessee
CROSSREF GENVEG,AIR-VEGC,DISTHIST,SPRFIR LEVEL LANDSCAPE,COMMUNITY
CITATIONS Pyle and Schafale 1985

PROJREG AIR-TRAC RMP 01 NOTRMP 2 GPSMSCI
PIs Edwards, N. T.
TITLE Soil and vegetation samples for chemical analysis
YEAR 1985- STATUS ONG
INST ORNL
CROSSREF SPRFIR,AIR-TRAC LEVEL ENVIRONMENTAL,PHYSIOLOGICAL
CITATIONS

PROJREG AIR-TRAC RMP 01 NOTRMP 2 GRSMSCI
PIs Huckabee, J. W.
TITLE Moss: a sensitive indicator of airborne mercury pollution
YEAR - STATUS
INST ORNL
CROSSREF AIR-VEGP LEVEL PHYSIOLOGICAL,ENVIRONMENTAL
CITATIONS

PROJREG AIR-TRAC RMP 01 NOTRMP 2 GRSMSCI
PIs Huckabee, J. W., and F. O. Hoffman
TITLE Environmental distribution and behavior of 99-TC
YEAR 1977- STATUS
INST ORNL
CROSSREF LEVEL PHYSIOLOGICAL
CITATIONS

PROJREG AIR-TRAC RMP 01 NOTRMP 1 GRSMSCI 1
PIs Luke, G.
TITLE Heavy metal loading in precipitation, streamwater, and tree rings, GRSM
YEAR - STATUS
INST Div. Air Poll. Contr, State of Tenn
CROSSREF AIR-VEGP,AIR-VEGT LEVEL PHYSIOLOGICAL,ENVIRONMENTAL
CITATIONS

PROJREG AIR-TRAC RMP 01.4.C.1 GRSMSCI 1
PIs McLaughlin, S. B.
TITLE Multi-elemental analysis of soil, litter, and vegetation
YEAR 1984-1985 STATUS PREP
INST ORNL
CROSSREF AIR-VEGP,SPRFIR LEVEL PHYSIOLOGICAL,ENVIRONMENTAL
CITATIONS Baes and McLaughlin, 1984, 1985, 1986; Baes et al. 1983

PROJREG AIR-TRAC RMP 01 NOTRMP 2 GRSMSCI
PIs McNeil, T. J.
TITLE Determination of lead levels associated with motor vehicle traffic within GRSM
YEAR 1976-1978 STATUS COMP
INST US Army-Env.Hy.
CROSSREF AIR-VEGP LEVEL PHYSIOLOGICAL,ENVIRONMENTAL
CITATIONS McNeil 1976

PROJREG AIR-TRAC RMP 01 NOTRMP 1 GRSMSCI 1
PIs Taylor, F. G., and P. D. Parr
TITLE Flouride survey of vegetation and soils of the Cades Cove Area, GRSM
YEAR 1982-1983 STATUS COMP
INST ORNL
CROSSREF AIR-VEGP LEVEL PHYSIOLOGICAL,ENVIRONMENTAL
CITATIONS Taylor and Parr 1983

PROJREG AIR-TRAC RMP 01 NOTRMP 1 GRSMSCI 1
PIs Turner, R. R.
TITLE Lead in vegetation, forest floor, and soils of the spruce-fir zone of GRSM
YEAR 1982-1984 STATUS COMP
INST ORNL
CROSSREF AIR-VEGP LEVEL PHYSIOLOGICAL,ENVIRONMENTAL
CITATIONS Bogle and Turner 1984; Turner et al. 1985

PROJREG AIR-TRAC RMP 01 NOTRMP 1 GRSMSCI 1
PIs Wiersma, G. B.
TITLE Trace element concentrations in soils and vegetation
YEAR 1976-1982 STATUS COMP
INST EPA-Las Vegas,EG&G
CROSSREF AIR-VEGP,SPRFIR LEVEL PHYSIOLOGICAL,ENVIRONMENTAL
CITATIONS Wiersma et al. 1978, 1979, 1980

PROJREG AIR-VEGC RMP 01 NOTRMP 1 GRSMSCI 1
PIs Skelly, J.
TITLE Air Quality Related Values in GRSM (AQRVs)
YEAR 1981-1981 STATUS COMP
INST VPI
CROSSREF AIR-VEGP LEVEL COMMUNITY,POPULATION
CITATIONS

PROJREG AIR-VEGC RMP 01 NOTRMP 1 GRSMSCI 1
PIs Williams, M. S. R.
TITLE Spruce dieback in GRSM
YEAR 1984- STATUS ONG
INST ORNL
CROSSREF AIR-SARR,AIR-VEGP,SPRFIR LEVEL PHYSIOLOGICAL
CITATIONS

PROJREG AIR-VEGP RMP 01.4.C.1 GRSMSCI 1
PIs Clebsch, E. E. C., R. T. Busing, and C. Eagar
TITLE Effects of atmospheric deposition and balsam woolly aphids on Fraser fir
YEAR 1984- STATUS ONG
INST UTennessee
CROSSREF SPRFIR LEVEL PHYSIOLOGICAL
CITATIONS

PROJREG AIR-VEGP RMP 01.4.C.4 GRSMSCI 1
PIs DeYourq, H. R., P. Sanchini, and J. Bennett
TITLE Establishment and assessment of white pine biomonitoring plots
YEAR 1984-1986 STATUS REPT
INST Northrup, Inc.,Butler,NPS-Air
CROSSREF PERMPLOT,AIR-VEGC LEVEL POPULATION,PHYSIOLOGICAL

PROJREG AIR-VEGP RMP 01.4.C.5 GRSMSCI 1
PIs Eckert, R. T.
TITLE White pine genetics and ozone
YEAR 1984-1986 STATUS PREP
INST UNew Hampshire
CROSSREF AIR-VEGC LEVEL PHYSIOLOGICAL,GENETICS
CITATIONS

PROJREG AIR-VEGP PMP 01 NOTRMP 1 GRSMSCI 1
PIs Esserlieu, M. K., R. J. Olson, and J. Bennett
TITLE Sensitivity of NPS Class I Areas to atmospheric pollutants
YEAR 1982-1983 STATUS PREP
INST ORNL,NPS-AIR
CROSSREF AIR-VEGC,AIR-VEGP,RARE LEVEL PHYSIOLOGICAL,GENERAL
CITATIONS Esserlieu and Olson, 1985;Bennett et al. 1985

PROJREG AIR-VEGP RMP 01 NCTRMP 1 GRSMSCI 1
PIs Karnosky, D. F., P. Berrang, and R. Mickler
TITLE A genecological evaluation of air pollution tolerance in hardwood trees
YEAR 1983- STATUS ONG
INST Michigan Tech,Cary Arboretum
CROSSREF AIR-VEGC LEVEL PHYSIOLOGICAL,GENETICS
CITATIONS Karnosky et al. 1984

PROJREG AIR-VEGP RMP 01.4.C.6 GRSMSCI 1
PIs Reinert, R.
TITLE Effects of ozone and other air pollutants on native and rare plants
YEAR 1983-1986 STATUS ONG
INST USDA-ACRS
CROSSREF RARE,SPRFIR LEVEL PHYSIOLOGICAL
CITATIONS

PROJREG AIR-VEGP RMP 01 NOTRMP 1 GRSMSCI 1
PIs Sanchini, P.
TITLE Biomonitoring at ozone monitoring stations
YEAR 1985- STATUS ONG
INST Holcomb Res Inst
CROSSREF PERMPLOT,AIR-VEGC LEVEL PHYSIOLOGICAL,COMMUNITY
CITATIONS

PROJREG AIR-VEGP RMP 01 NOTRMP 1 GRSMSCI 1
PIs Skelly, J. M., N. T. Stephens, and L. W. Kress
TITLE Air quality measurements in GRSM and relationships to vegetation injury
YEAR 1978- STATUS
INST VPI
CROSSREF AIR-VEGC LEVEL PHYSIOLOGICAL
CITATIONS Skelly et al. 1981

PROJREG AIR-VEGT RMP 01.4.C.1 GRSMSCI 1
PIs Bruck, R. I., and W. P. Robarge
TITLE Observations of boreal montane forest decline--soil and vegetation studies
YEAR 1984-1985 STATUS PREP
INST NCSU
CROSSREF AIR-SARR,AIR-VEGC,AIR-VEGP,AIR-TERC LEVEL PHYSIOLICAL,COMMUNITY
CITATIONS Bruck and Robarge 1986

PROJREG AIR-VEGT RMP 01 NOTRMP 1 GRSMSCI
PIs Cogbill, C. V.
TITLE The effects of acid precipitation on tree growth in eastern North America
YEAR 1976-1977 STATUS COMP
INST Cornell
CROSSREF AIR-VEGP,SPRFIR LEVEL PHYSIOLOGICAL
CITATIONS Cogbill 1977

PROJREG AIR-VEGT RMP 01 NOTRMP 1 GRSMSCI 1
PIs Cook, E. R.
TITLE Development of an eastern network of tree-ring chronologies for the study of climate
YEAR 1983-1986 STATUS ONG
INST Lamont-Doherty Geophys Lab
CROSSREF AIR-VEGP,SPRFIR LEVEL PHYSIOLOGICAL
CITATIONS

PROJREG AIR-VEGT RMP 01 NOTRMP 1 GRSMSCI 1
PIs Johnson, A. H., and A. Friedlander
TITLE Evaluation of red spruce vigor and mortality in high elevation forest, eastern United States
YEAR 1982- STATUS COMP
INST UPennsylvania
CROSSREF AIR-VEGP,SPRFIR LEVEL PHYSIOLOGICAL,POPULATION
CITATIONS

PROJREG AIR-VEGT RMP 01.4.C.1 GRSMSCI 1
PIs McLaughlin, S. B.
TITLE Analysis of forest growth responses to air pollution stress (FORAST)
YEAR 1982-1985 STATUS PREP
INST ORNL
CROSSREF AIR-TRAC,AIR-VEGP,SPRFIR LEVEL POPULATION,PHYSIOLOGICAL
CITATIONS McLaughlin 1983, 1985

PROJREG AIR-VEGT RMP 01.4.C.1 GRSMSCI 1
PIs McLaughlin, S. B., S. Adams, T. J. Blasing, and D. N. Duvick
TITLE A survey of growth trend decline in spruce in GRSM
YEAR 1983-1985 STATUS PREP
INST ORNL,Dabney Lancaster
CROSSREF AIR-TRAC,AIR-VEGP,SPRFIR LEVEL POPULATION,PHYSIOLOGICAL
CITATIONS

PROJREG BIBLIOG RMP 15 NOTRMP 2 GRSMSCI
PIs Bailey, J.
TITLE Bibliography of Fraser fir
YEAR 1983-1985 STATUS COMP
INST VPI
CROSSREF GENERAL,AIP-SARR,BWA,GENDIVEP LEVEL GENERAL
CITATIONS Bailey 1985

PROJREG BIBLIOG RMP 26 NOTRMP 1 GRSMSCI 1
PIs Carpenter, D.
TITLE Impacts and influences on Great Smoky Mountains National Park: an annotated bibliography
YEAR 1980-1982 STATUS COMP
INST WCarolina

PROJREG BIBLIOG RMP 26.4.C.6 GRSMSCI 1
PIs DePriest, P.
TITLE Bibliography of southern Appalachian lichens
YEAR 1982-1985 STATUS COMP
INST UTennessee
CROSSREF AIR-LICH,LICHENS,GENERAL LEVEL GENERAL,CHECKLIST
CITATIONS DePriest 1984

PROJREG BIBLIOG RMP 26.4.C.6 GRSMSCI 1
PIs DeYoung, H. R., P. S. White, and H. R. DeSelm
TITLE Bibliography of southern Appalachian vegetation
YEAR 1978-1982 STATUS COMP
INST NPS-UPL,UTennessee
CROSSREF GENVEG LEVEL LANDSCAPE,COMMUNITY,GENERAL
CITATIONS DeYoung et al. 1982

PROJREG BIBLIOG RMP 26.4.C.6 GRSMSCI 1
PIs Evans, M., P. S. White, and C. Pyle
TITLE Bibliography of southern Appalachian pteridophytes
YEAR 1980-1981 STATUS COMP
INST NPS
CROSSREF FLORA LEVEL CHECKLIST,GENERAL
CITATIONS Evans et al. 1981

PROJREG BIBLIOG RMP 26 NOTRMP 1 GRSMSCI 1
PIs McCrone, J., A. Stocum, and F. Huber
TITLE History and bibliography of scientific study
YEAR 1981-1982 STATUS COMP
INST WCarolina,SARRMC
CROSSREF LEVEL GENERAL
CITATIONS McCrone et al. 1982, 1982

PROJREG BIBLIOG RMP 26.4.C.6 GRSMSCI 1
PIs Springer, M. E., and P. S. White
TITLE Bibliography of southern Appalachian soils
YEAR 1982-1986 STATUS PREP
INST UTennessee,NPS-UPL,NPS-CPSU
CROSSREF LEVEL LEVEI,ECOSYSTEM,ENVIRONMENT
CITATIONS Springer and White, in press

PROJREG BIBLIOG RMP 26.4.C.6 GRSMSCI 1
PIs Wofford, B. E., and P. S. White
TITLE Bibliography of southern Appalachian phanerophytes
YEAR 1979-1982 STATUS COMP
INST NPS-UPL,UTennessee
CROSSREF FLORA,RARE LEVEL GENERAL,CHECKLIST
CITATIONS Wofford and White 1981

PROJREG BIBLIOG RMP 26.4.C.6 GRSMSCI 1
PIs Yurkovich, S.
TITLE Bibliography on southern Appalachian geology and geomorphology
YEAR 1981-1984 STATUS COMP
INST WCarolina
CROSSREF GEOLOGY LEVEL ENVIRONMENTAL
CITATIONS Yurkovitz 1984

PROJREG BIGTREE RMP BDATA NOTRMP 1 GRSMSCI
PIs Korn, W.
TITLE Tennessee state record trees in GRSM
YEAR 1980- STATUS
INST Tennessee Conserv. Dept.
CROSSREF DISTHIST LEVEL POPULATION
CITATIONS

PROJREG BIGTREE RMP BDATA NOTRMP 1 GRSMSCI 1
PIs White, P. S.
TITLE National, state, and park champion trees
YEAR 1978- STATUS ONG
INST NPS-UPL,NPS-CPSU
CROSSREF FLORA LEVEL POPULATION
CITATIONS

PROJREG BRYOPHYT RMP BDATA NOTRMP 2 GRSMSCI
PIs Arzeni, C. B.
TITLE Ecological observations on bryophytes
YEAR 1974- STATUS
INST EIllinois U
CROSSREF GENVEG LEVEL COMMUNITY
CITATIONS

PROJREG BRYOPHYT RMP BDATA NOTRMP 2 GRSMSCI
PIs Bowers, F. D.
TITLE General collecting--bryophytes
YEAR 1972- STATUS
INST UTennessee
CROSSREF LEVEL CHECKLIST
CITATIONS

PROJREG BRYOPHYT RMP BDATA NOTRMP 2 GRSMSCI
PIs Dubois, S. R.
TITLE General collecting--mosses and lichens
YEAR 1980- STATUS
INST NPS-INTERP
CROSSREF LICHENS LEVEL CHECKLIST
CITATIONS

PROJREG BRYOPHYT RMP BDATA NOTRMP 2 GRSMSCI
PIs Fairbarns, M.
TITLE Regeneration and copper relationships--bryophytes
YEAR 1976- STATUS
INST UGuelph
CROSSREF AIR-TRAC LEVEL PHYSIOLOGICAL
CITATIONS

PROJREG BRYOPHYT RMP BDATA NOTRMP 2 GRSMSCI
PIs Huntzinger, G.
TITLE Aspectual distribution of bryophytes on Aesculus octandra
YEAR 1982-1985 STATUS COMP
INST UTennessee
CROSSREF GENVEG LEVEL COMMUNITY

PROJREG BRYOPHYT RMP BDATA NOTRMP 2 GRSMSCI
PIs Mescall, Y.
TITLE Bryophyte distribution in cove hardwood forest
YEAR 1982- STATUS ONG
INST UTennessee
CROSSREF GENVEG LEVEL COMMUNITY
CITATIONS

PROJREG BRYOPHYT RMP BDATA NOTRMP 2 GRSMSCI
PIs Perry, J. F.
TITLE Distribution patterns of epiphytic bryophytes
YEAR 1977- STATUS ABAN
INST UTennessee
CROSSREF GENVEG LEVEL COMMUNITY
CITATIONS

PROJREG BRYOPHYT RMP BDATA NOTRMP 2 GRSMSCI
PIs Sharp, A. J.
TITLE General collecting and floristics--bryophytes
YEAR 1929- STATUS ONG
INST UTennessee
CROSSREF LEVEL CHECKLIST
CITATIONS Sharp 1938, 1939, 1941

PROJREG BRYOPHYT RMP BDATA NOTRMP 2 GRSMSCI
PIs Smith, D. K.
TITLE General floristics--bryophytes
YEAR - STATUS
INST UTennessee
CROSSREF LEVEL SYSTEMATICS,CHECKLIST
CITATIONS

PROJREG BRYOPHYT RMP BDATA NOTRMP 2 GRSMSCI
PIs Spessard, L. L.
TITLE General collecting--bryophytes
YEAR 1974- STATUS ABAN
INST UTennessee
CROSSREF LEVEL CHECKLIST
CITATIONS

PROJREG BRYOPHYT RMP BDATA NOTRMP 2 GRSMSCI
PIs Webster, H. J.
TITLE Bryophytic flora and ecology of GRSM
YEAR 1972- STATUS
INST UTennessee
CROSSREF GENVEG,FLORA LEVEL CHECKLIST,COMMUNITY
CITATIONS PhD Dissertation at UT-BOTANY

PROJREG BWA RMP 15 NOTRMP 1 GRSMSCI
PIs Arthur, F. H., and F. P. Hain
TITLE Seasonal history of the balsam woolly adelgid in natural stands and plantations of Fraser fir
YEAR 1984- STATUS
INST NC State
CROSSREF AIR-VEGP,AIR-SAPR,DISTHIST LEVEL PHYSIOLOGICAL
CITATIONS Arthur and Hain 1984

PROJREG BWA RMP 15.4.B.1 GRSMSCI 1
PIs Berg, D.
TITLE Monitoring of the balsam woolly adelgid control program
YEAR 1982- STATUS ONG
INST NPS-RM,USFS
CROSSREF PERMPLOT LEVEL PHYSIOLOGICAL,POPULATION
CITATIONS

PROJREG BWA RMP 15 NOTRMP 1 GRSMSCI
PIs Boner, R. R.
TITLE Understory changes in spruce-fir during the first 16-20 years following the death of fir
YEAR 1983- STATUS
INST UTennessee,MN-Nat Conserv
CROSSREF AIR-SARR LEVEL COMMUNITY
CITATIONS Boner 1979; DeSelm and Boner 1984

PROJREG BWA RMP 15 NOTRMP 1 GRSMSCI 1
PIs Gardner, R., D. DeAngeles, and V. Dale
TITLE Model of balsam woolly adelgid-Fraser fir interactions
YEAR 1985- STATUS ONG
INST ORNL
CROSSREF MODEL,GENVEG LEVEL COMMUNITY,PHYSIOLOGICAL,LANDSC
CITATIONS

PROJREG BWA RMP 15 NOTRMP 1 GRSMSCI 1
PIs Hay, R., C. Eagar, and K. Johnson
TITLE Fraser fir: its demise by the balsam woolly aphid (Adelges piceae Ratz.)
YEAR 1976-1978 STATUS COMP
INST UTennessee
CROSSREF AIR-SARR LEVEL PHYSIOLOGICAL,POPULATION
CITATIONS Eagar 1978, 1984, 1985; Hay 1980; Hay et al. 1976, 1978; Johnson 1977, 1980

PROJREG CHESTNUT RMP 14 NOTRMP 2 GRSMSCI
PIs Barnett, P. E., and E. Thor
TITLE Phenolics in chestnut resistance to blight
YEAR 1968-1972 STATUS COMP
INST UTennessee
CROSSREF FLORA,GENVEG,GENETICS LEVEL POPULATION GENETICS,PHYSIOLOGY
CITATIONS

PROJREG CHESTNUT RMP 14 NOTRMP 2 GRSMSCI
PIs Flora, D. F.
TITLE The American chestnut as an allelopath
YEAR 1976-1977 STATUS COMP
INST UTennessee
CROSSREF LEVEL COMMUNITY
CITATIONS Flora 1977

PROJREG CHESTNUT RMP 14 NOTRMP 2 GRSMSCI
PIs Nash, B.
TITLE Potential occurrence of hypovirulent Endothia parasitica
YEAR 1979- STATUS
INST Duke
CROSSREF GENVEG,FUNGI LEVEL PHYSIOLOGICAL,POPULATION

PROJREG DISTHIST RMP 26 NOTRMP 1 GRSMSCI
PIs LaBerge, J.
TITLE Virgin forests of eastern North America
YEAR 1978- STATUS ONG
INST PRIV
CROSSREF VEGMAP,FIRE,GENVEG LEVEL LANDSCAPE,COMMUNITY
CITATIONS

PROJREG DISTHIST RMP 26 NOTRMP 1 GRSMSCI
PIs McCracken, W.
TITLE Forest cover prior to and following the disturbance of logging in GRSM
YEAR 1975- STATUS
INST UTennessee
CROSSREF GENVEG LEVEL LANDSCAPE,COMMUNITY
CITATIONS Buckner and McCracken 1978; McCracken 1978

PROJREG DISTHIST RMP 26.4.C.5 GRSMSCI 1
PIs Pyle, C.
TITLE GRSM disturbance history--an assesment of archival maps and records
YEAR 1982-1985 STATUS COMP
INST NPS-UPL
CROSSREF FIRE,SPRFIR,VEGMAP,GRASSYB,AIR-SARR LEVEL LANDSCAPE
CITATIONS Pyle 1984, 1985

PROJREG DISTHIST RMP 26 NOTRMP 1 GRSMSCI 1
PIs Pyle, C.
TITLE Location of CCC camps in GRSM
YEAR 1979-1981 STATUS COMP
INST NPS-UPL
CROSSREF LEVEL LANDSCAPE
CITATIONS

PROJREG ECOSYST RMP 26 NOTRMP 1 GRSMSCI 1
PIs Swank, W. T., and R. Wall
TITLE Nitrogen dynamics of forest ecosystems in GRSM
YEAR 1980-1982 STATUS PREP
INST USFS-Coweeta,NCarolina
CROSSREF AIR-ECOS,AIR-VEGP,HOGS LEVEL ECOSYSTEM
CITATIONS

PROJREG EIS RMP 13 NOTRMP 1 GPSMSCI 1
PIs Baron, J., J. R. Zucchino, and S. P. Bratton
TITLE Environmental assessment of the proposed extension of the Blue Ridge Parkway
YEAR 1976-1977 STATUS COMP
INST NPS-UPL
CROSSREF GENVEG,VEGMAP LEVEL COMMUNITY
CITATIONS Baron 1976

PROJREG EIS RMP 13 NOTRMP 1 GPSMSCI 1
PIs Baron, J., and R. C. Mathews, Jr.
TITLE Environmental assessment of alternatives for the Foothills Parkway
YEAR 1977-1977 STATUS COMP
INST NPS-UPL
CROSSREF GENVEG LEVEL COMMUNITY,ENVIRONMENTAL
CITATIONS Baron and Mathews 1977

PROJREG ETHNOBOT RMP MAB-GEN NOTRMP 1 GRSMSCI 1
PIs Campbell, J., A. Bailey, and G. Darugh
TITLE Ethnobiology of the southern Appalachians
YEAR 1983-1985 STATUS REV
INST Tennessee St,UTennessee,Tennessee T
CROSSREF FLORA,BIBLIOG,GENDIVER LEVEL GENERAL
CITATIONS Campbell et al., 1985, In review; Bailey 1985

PROJREG EXPLANTS RMP 08 NOTRMP 1 GRSMSCI 1
PIs Baron, J., C. Dombrowski, and S. P. Bratton
TITLE Survey of five exotic plants in the Tennessee District
YEAR 1975-1975 STATUS COMP
INST NPS-UPL
CROSSREF LEVEL POPULATION
CITATIONS Baron et al. 1975, 1976

PROJREG EXPLANTS RMP 08.4.B.1 GRSMSCI 1
PIs Berg, D.
TITLE Exotic plant monitoring and data base
YEAR 1982- STATUS ONG
INST NPS-RM
CROSSREF LEVEL POPULATION
CITATIONS

PROJREG EXPLANTS RMP 08 NOTRMP 1 GRSMSCI 1
PIs Bratton, S. P., and P. S. White
TITLE Exotic plant surveys at Southeast Region upland Parks
YEAR 1980-1982 STATUS COMP
INST NPS-UPL
CROSSREF LEVEL POPULATION
CITATIONS Butler and White 1981, Butler et al. 1981, Rosen et al. 1982

PROJREG EXPLANTS RMP 08 NOTRMP 1 GRSMSCI 1
PIs Gardner, D. E.
TITLE Biological control of mimosa trees
YEAR 1975- STATUS COMP
INST NPS-BStL
CROSSREF LEVEL POPULATION
CITATIONS

PROJREG EXPLANTS RMP 08 NOTRMP 1 GRSMSCI 1
PIs Rosen, A.
TITLE Kudzu eradication experiments
YEAR 1980-1982 STATUS COMP
INST NPS-UPL,UTennessee
CROSSREF LEVEL POPULATION
CITATIONS Rosen 1982

PROJREG FIRE RMP 11 NOTRMP 1 GRSMSCI
PIs Barden, L.
TITLE Characteristics of lightning and human set fires in the southern Appalachian mountains
YEAR 1972-1974 STATUS COMP
INST UTennessee
CROSSREF DISTHIST,GENVEG LEVEL LANDSCAPE

PROJREG FIRE RMP 11.4.C.3 GRSMSCI 1
PIs Berq, D.
TITLE Fire records of GRSM
YEAR 1983- STATUS ONG
INST NPS-RM
CROSSREF DISTHIST,GENVEG LEVEL LANDSCAPE
CITATIONS

PROJREG FIRE PMP 11 NOTRMP 1 GRSMSCI 1
PIs Harmon, M. E.
TITLE GRSM fire history, 1940-1979
YEAR 1977-1981 STATUS COMP
INST NPS-UPL
CROSSREF DISTHIST,GENVEG LEVEL LANDSCAPE
CITATIONS Harmon 1981

PROJREG FIRE RMP 11 NOTRMP 1 GRSMSCI 1
PIs Harmon, M. E.
TITLE The distribution, dynamics, and dimensions of forest fuels
YEAR 1976-1980 STATUS COMP
INST NPS-UPL
CROSSREF ECOSYST,GENVEG,PERMPLOT LEVEL COMMUNITY,ECOSYSTEM
CITATIONS Harmon 1981, 1981; Harmon et al. 1980

PROJREG FIRE RMP 11 NOTRMP 1 GRSMSCI 1
PIs Harmon, M. E.
TITLE Decomposition of standing dead trees in the southern Appalachian mountains
YEAR 1980-1982 STATUS COMP
INST NPS-UPL
CROSSREF GENVEG,PERMPLOT LEVEL COMMUNITY,ECOSYSTEM
CITATIONS Harmon 1982

PROJREG FIRE RMP 11 NOTRMP 1 GRSMSCI 1
PIs Harmon, M. E.
TITLE Fire history of western GRSM
YEAR 1978-1982 STATUS COMP
INST NPS-UPL
CROSSREF GENVEG,DISTHIST LEVEL COMMUNITY,LANDSCAPE
CITATIONS Harmon 1981, 1982

PROJREG FIRE RMP 11 NOTRMP 1 GRSMSCI 1
PIs Harmon, M. E.
TITLE Permanent plots: succession after fire Polecat Ridge and Hannah Mt
YEAR 1977- STATUS ONG
INST NPS-UPL,UTennessee,Oregon St
CROSSREF DISTHIST,GENVEG,PERMPLOT LEVEL COMMUNITY
CITATIONS Harmon 1981, 1984

PROJREG FIRE RMP 11 NOTRMP 1 GRSMSCI 1
PIs Harmon, M. E.
TITLE Development of the fire documentation system
YEAR 1977-1978 STATUS COMP
INST NPS-UPL
CROSSREF DISTHIST LEVEL LANDSCAPE
CITATIONS

PROJREG FIRE RMP 11.4.C.1 GPSMSCI 1
PIs Nicholas, N. S.
TITLE Permanent plots: inventory of forest fuels
YEAR 1982-1985 STATUS PREP
INST NPS-UPL,UTennessee
CROSSREF PERMPLOT,GENVEG,VEGMAP,DISTHIST LEVEL COMMUNITY
CITATIONS Nicholas Unpublished, 1984, In review

PROJREG FIRE RMP 15.4.C.1 GPSMSCI 1
PIs Nicholas, N. S., and P. S. White
TITLE The effect of balsam woolly adelgid infestations on fuel levels
YEAR 1983-1984 STATUS COMP
INST NPS-UPL
CROSSREF GENVEG,BWA,SPRFIR,VEGMAP,DISTHIST,AIR-SARR LEVEL COMMUNITY
CITATIONS Nicholas and White 1985

PROJREG FIRE RMP 11.4.C.1 GPSMSCI 1
PIs Nicholas, N. S., and P. S. White
TITLE The effect of southern pine beetle infestations on fuel levels
YEAR 1983-1984 STATUS COMP
INST NPS-UPL
CROSSREF GENVEG,VEGMAP,SOPINEBE,DISTHIST LEVEL COMMUNITY
CITATIONS Nicholas and White 1984

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Adams, A. B.
TITLE Chemical analysis of flavenoids in Trillium
YEAR 1974- STATUS COMP
INST UTennessee
CROSSREF LEVEL SYSTEMATICS,CHEMISTRY
CITATIONS Adams 1975

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Adams, R. W., II
TITLE Systematics of Lilium
YEAR 1978- STATUS
INST Cornell
CROSSREF LEVEL SYSTEMATICS
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Athey, R.
TITLE Taxonomy of grasses in GRSM
YEAR 1978-1978 STATUS COMP
INST Memphis State
CROSSREF LEVEL SYSTEMATICS
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Bostick, P. E.
TITLE Oil extract from Angelica triquinnata
YEAR 1984- STATUS
INST Emory
CROSSREF LEVEL PHYTOCHEMISTRY

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Boufford, D. E.
TITLE General collecting--Joint Chinese-American field trip for vascular plants
YEAR 1982-1982 STATUS COMP
INST Harvard U
CROSSREF LEVEL CHECKLIST
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Brink, D.
TITLE Biosystematics and ecology of Aconitum
YEAR - STATUS
INST UIllinois-Urbana
CROSSREF GENVEG LEVEL SYSTEMATICS,POPULATION
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Christy, C.
TITLE Systematics of Hieracium
YEAR 1983- STATUS ONG
INST UTennessee
CROSSREF RARE LEVEL SYSTEMATICS
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Cousens, M. I.
TITLE General collecting--woody plants
YEAR 1983-1983 STATUS COMP
INST UWest Florida
CROSSREF LEVEL CHECKLIST
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs DeLanglade, R. A.
TITLE General collecting--vascular plants
YEAR 1980- STATUS ONG
INST Wittenberg U
CROSSREF LEVEL CHECKLIST
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Evans, A. M.
TITLE General collecting--ferns
YEAR - STATUS ONG
INST UTennessee
CROSSREF LEVEL SYSTEMATICS,CHECKLIST
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Fusiak, F.
TITLE Systematics of the Prenanthes roanensis complex
YEAR 1978-1983 STATUS COMP
INST UTennessee
CROSSREF RARE LEVEL CHECKLIST,POPULATION
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Hawden, R. S.
TITLE General collecting--pteridophytes
YEAR 1976-1976 STATUS COMP
INST UGuelph
CROSSREF LEVEL CHECKLIST
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Held, M. E.
TITLE Racial differentiation in Fagus grandifolia
YEAR 1981- STATUS
INST St Peter's Coll
CROSSREF GENVEG LEVEL SYSTEMATICS
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Helena, M. L.
TITLE General collecting--pine
YEAR 1982-1982 STATUS COMP
INST Private
CROSSREF LEVEL CHECKLIST
CITATIONS

PROJREG FLORA RMP MAB-GEN NOTRMP 2 GRSMSCI
PIs Hendrix, K.
TITLE General collecting--table mountain pine cones
YEAR 1982-1982 STATUS COMP
INST NCState
CROSSREF GENDIVER LEVEL SEED COLLECTION
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Hughes, K.
TITLE Evolution of Mimulus
YEAR - STATUS AEAN
INST UTennessee
CROSSREF LEVEL SYSTEMATICS
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 1 GRSMSCI
PIs Jenkins, J.
TITLE General collecting--vascular plants
YEAR 1982- STATUS
INST Williams Coll
CROSSREF LEVEL CHECKLIST
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Jones, ??
TITLE Biosystematic study of Viburnum of eastern North America
YEAR 1974- STATUS
INST NCState
CROSSREF LEVEL SYSTEMATICS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Kellogg, E. A.
TITLE Poa in the Southeast
YEAR 1982- STATUS
INST Harvard U
CROSSREF LEVEL SYSTEMATICS
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Lewis, W. H.
TITLE Evolutionary study of Claytonia
YEAR 1972- STATUS COMP
INST Washington Univ
CROSSREF LEVEL SYSTEMATICS
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Lynch, S. P.
TITLE General collecting--vascular plants
YEAR 1978-1978 STATUS COMP
INST LSU-Shreveport
CROSSREF LEVEL CHECKLIST
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs MacFarland, K. D., and D. K. Smith
TITLE Coastal plain plants in Cades Cove
YEAR 1976- STATUS
INST WCarolina
CROSSREF GENVEG,RARE LEVEL CHECKLIST
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs McCormack, ??
TITLE Beetle pollination of Calycanthus
YEAR 1973- STATUS
INST UConnecticut
CROSSREF LEVEL POLLINATION ECOLOGY
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Melampy, M.
TITLE Comparative breeding ecology of Thalictrum spp.
YEAR 1975- STATUS
INST UIllinois
CROSSREF LEVEL POLLINATION ECOLOGY
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 1 GRSMSCI
PIs Miller, F. H.
TITLE General collecting--woody plants of east Tennessee and western North Carolina
YEAR 1968- STATUS ONG
INST Private
CROSSREF LEVEL CHECKLIST
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Odenwelder, J. E.
TITLE General collecting--fern allies of Tennessee
YEAR 1971- STATUS COMP
INST UTennessee
CROSSREF LEVEL SYSTEMATICS
CITATIONS MS THESIS AT UT-BOTANY

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Ostby, B.
TITLE General collecting--woody plants of high elevations
YEAR 1985-1986 STATUS COMP
INST
CROSSREF LEVEL CHECKLIST
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Pallmyr, O.
TITLE Pollination ecology of Actaea and Cimicifuga
YEAR 1981- STATUS
INST Univ of Uppsala
CROSSREF GENVEG LEVEL POLLINATION ECOLOGY
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Patrick, T.
TITLE Orchids of Tennessee
YEAR 1982- STATUS ONG
INST UTennessee
CROSSREF RARE LEVEL CHECKLIST
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Patrick, T.
TITLE Systematics of Trillium
YEAR 1978- STATUS ONG
INST UTennessee
CROSSREF RARE LEVEL CHECKLIST,POPULATION
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Pearman, R. W.
TITLE Biosystematic study of Cystopteris
YEAR 1974- STATUS ABAN
INST UTennessee
CROSSREF LEVEL SYSTEMATICS
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Phillippe, L. P.
TITLE Hybridization of Sanicula
YEAR 1976-1978 STATUS COMP
INST UTennessee
CROSSREF LEVEL SYSTEMATICS

PROJREG FLORA RMP BDATA NOTRMP 1 GRSMSCI
PIs Pittillo, J. D.
TITLE General collecting--vascular plants
YEAR 1972- STATUS ONG
INST WCarolina
CROSSREF RARE LEVEL CHECKLIST
CITATIONS Pittillo et al. 1969, 1972, 1975

PROJREG FLORA RMP BDATA NOTRMP 1 GRSMSCI
PIs Pyle, C.
TITLE General collecting--woody plant teaching collection
YEAR 1981-1983 STATUS COMP
INST NPS-UPL
CROSSREF LEVEL CHECKLIST
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Pader, L. R.
TITLE Biosystematics of Viburnum
YEAR 1974-1976 STATUS COMP
INST UTennessee
CROSSREF LEVEL SYSTEMATICS
CITATIONS MS THESIS AT UT-BOTANY

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Reich, R. J.
TITLE General collecting--botany
YEAR 1976- STATUS
INST Milwaukee Area Tech
CROSSREF GENVEG LEVEL CHECKLIST
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Sharp, A. J.
TITLE General collecting--bryophytes and vascular plants
YEAR 1929- STATUS ONG
INST UTennessee
CROSSREF BRYOPHYT LEVEL SYSTEMATICS,CHECKLIST
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Sorensen, P.
TITLE General collecting--spring flora of GRSM
YEAR 1979-1979 STATUS COMP
INST No Illinois U
CROSSREF LEVEL CHECKLIST
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Volman, K.
TITLE Anatomical studies of eastern hardwoods
YEAR 1978- STATUS
INST Texas A&M
CROSSREF LEVEL SYSTEMATICS
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 1 GRSMSCI 1
PIs Waggoner, G. S.
TITLE NPFLORA--checklist for GRSM
YEAR 1982-1984 STATUS COMP
INST NPS
CROSSREF LEVEL CHECKLIST
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Warren, D. K.
TITLE General collecting--vascular plants
YEAR 1982-1983 STATUS COMP
INST Principia Coll
CROSSREF LEVEL CHECKLIST
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Waterway, M. J.
TITLE Systematics of Carex debilis
YEAR 1983- STATUS
INST Cornell
CROSSREF LEVEL SYSTEMATICS
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Wayne, P., and J. Erb
TITLE General collecting--vascular plants
YEAR 1981-1981 STATUS COMP
INST Coll Atlantic
CROSSREF LEVEL CHECKLIST
CITATIONS

PROJREG FLORA RMP 25.4.B.1 GRSMSCI 1
PIs White, P. S.
TITLE Flora of limestone areas, lower Abrams Creek, and other special floristic areas
YEAR 1978- STATUS ONG
INST NPS-UPL,NPS-CPSU
CROSSREF PERMPLOT,GENVEG,SPECPROT LEVEL CHECKLIST,POPULATION,COMMUNITY
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 1 GRSMSCI 1
PIs White, P. S.
TITLE Vascular plant checklist and data base
YEAR 1975-1986 STATUS PREP
INST NPS-UPL
CROSSREF RARE,EXPLANTS LEVEL CHECKLIST
CITATIONS White 1982, 1982, 1983, 1984; White and Renfro 1984

PROJREG FLORA RMP BDATA NOTRMP 1 GRSMSCI 1
PIs White, P. S.
TITLE Computerization of herbarium records
YEAR 1978-1982 STATUS PREP
INST NPS-UPL
CROSSREF RARE LEVEL CHECKLIST

PROJREG FLORA RMP 26 NOTRMP 1 GRSMSCI 1
PIs White, P. S., and G. S. Ramseur
TITLE Island biogeography of the high peaks of the southern Appalachians: vascular plants
YEAR 1982-1984 STATUS COMP
INST NPS-UPL,USouth
CROSSREF FLORA,ISLANDS LEVEL CHECKLIST,COMMUNITY
CITATIONS White et al. 1984

PROJREG FLORA RMP 26 NOTRMP 1 GRSMSCI 1
PIs White, P. S., and R. L. Jones
TITLE Botanical assessment of Shiloh National Military Park
YEAR 1980-1981 STATUS COMP
INST NPS-UPL,Vanderbilt
CROSSREF RARE,EXPLANTS LEVEL CHECKLIST,POPULATION
CITATIONS Jones and White 1981; Jones 1983

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Whitford, P. B.
TITLE General collecting--vascular plants
YEAR - STATUS
INST UWisconsin-Milwaukee
CROSSREF LEVEL CHECKLIST
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Yates, H. O.
TITLE General collecting--vascular plants
YEAR 1981-1981 STATUS COMP
INST David Lipscomb Coll
CROSSREF LEVEL CHECKLIST
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Zhihao, H.
TITLE General collecting--vascular plants
YEAR 1984-1984 STATUS COMP
INST WCarolina
CROSSREF LEVEL CHECKLIST
CITATIONS

PROJREG FLORA RMP BDATA NOTRMP 2 GRSMSCI
PIs Zika, P. F., and J. Donnelly
TITLE General collecting--vascular plants
YEAR 1981- STATUS
INST UVermont
CROSSREF LEVEL CHECKLIST
CITATIONS

PROJREG FUNGI RMP BDATA NOTRMP 2 GRSMSCI
PIs Badham, F.
TITLE Taxonomy of dark spored agarics
YEAR 1976-1976 STATUS COMP
INST UTennessee
CROSSREF LEVEL SYSTEMATICS
CITATIONS

PROJREG FUNGI RMP BDATA NOTRMP 2 GRSMSCI
PIs Baird, R. E.
TITLE Stipitate hydnums
YEAR 1979- STATUS
INST UTennessee
CROSSREF LEVEL SYSTEMATICS
CITATIONS PhD DISSERTATION AT UT-BOTANY

PROJREG FUNGI RMP BDATA NOTRMP 2 GRSMSCI
PIs Cooke, W. B.
TITLE Fungi of GRSM
YEAR 1980- STATUS
INST Private
CROSSREF LEVEL CHECKLIST
CITATIONS

PROJREG FUNGI RMP BDATA NOTRMP 2 GRSMSCI
PIs Dyko, B. J.
TITLE Survey of Hyphomycetes of the Southeast
YEAR 1974-1977 STATUS COMP
INST UTennessee
CROSSREF LEVEL SYSTEMATICS
CITATIONS Dyko 1977

PROJREG FUNGI RMP BDATA NOTRMP 2 GRSMSCI
PIs Freeman, A. E. H.
TITLE Agaricus of the southeast
YEAR 1973-1977 STATUS COMP
INST UTennessee
CROSSREF LEVEL SYSTEMATICS
CITATIONS PhD Dissertation at UT-BOTANY

PROJREG FUNGI RMP BDATA NOTRMP 2 GRSMSCI
PIs Freeman, G. W.
TITLE Taxonomy of Gloeocystidiellum of North America
YEAR 1975-1977 STATUS COMP
INST UTennessee
CROSSREF LEVEL SYSTEMATICS
CITATIONS PhD Dissertation at UT-BOTANY

PROJREG FUNGI RMP BDATA NOTRMP 2 GRSMSCI
PIs Hamilton, S. H.
TITLE General collecting--funqi
YEAR 1984- STATUS
INST
CROSSREF LEVEL CHECKLIST
CITATIONS

PROJREG FUNGI RMP BDATA NOTRMP 2 GRSMSCI
PIs Hesler, L. R.
TITLE Monographic studies of North American Agaricales
YEAR 1925-1976 STATUS COMP
INST UTennessee
CROSSREF LEVEL SYSTEMATICS

PROJREG FUNGI RMP. BDATA NOTRMP 2 GRSMSCI
PIs Holton, R. W.
TITLE Phytochemical studies of fleshy fungi
YEAR 1975-1979 STATUS COMP
INST UTennessee
CROSSREF LEVEL SYSTEMATICS
CITATIONS

PROJREG FUNGI RMP BDATA NOTRMP 2 GRSMSCI
PIs Jackson, R. D.
TITLE General collecting--Mushrooms
YEAR 1980- STATUS
INST Private
CROSSREF LEVEL CHECKLIST
CITATIONS

PROJREG FUNGI RMP BDATA NOTRMP 2 GRSMSCI
PIs Jenkins, D. T.
TITLE Monograph of Amanita
YEAR 1972-1974 STATUS COMP
INST UTennessee
CROSSREF LEVEL SYSTEMATICS
CITATIONS PhD Dissertation at UT-BOTANY

PROJREG FUNGI RMP BDATA NOTRMP 1 GRSMSCI
PIs Jung, H. S.
TITLE Resupinate fungi of spruce-fir forest in GRSM
YEAR 1981-1985 STATUS COMP
INST UTennessee
CROSSREF SPRFIR,AIR-SARR LEVEL POPULATION,CHECKLIST
CITATIONS Jung 1985

PROJREG FUNGI RMP BDATA NOTRMP 1 GRSMSCI 1
PIs Liebman, J. A.
TITLE Type specimens of fungi from GRSM
YEAR 1979-1981 STATUS COMP
INST UTennessee
CROSSREF LEVEL CHECKLIST
CITATIONS

PROJREG FUNGI RMP BDATA NOTRMP 2 GRSMSCI
PIs Luther, B.
TITLE Study of the fungus genus Lindtneria in North America
YEAR 1978-1979 STATUS ABAN
INST UTennessee
CROSSREF LEVEL SYSTEMATICS
CITATIONS

PROJREG FUNGI RMP BDATA NOTRMP 2 GRSMSCI
PIs Mahoney, A. M.
TITLE Cyclopeptides in Amanita mushrooms
YEAR 1975-1977 STATUS COMP
INST UTennessee
CROSSREF GENDIVER LEVEL SYSTEMATICS
CITATIONS Mahoney 1977

PROJREG FUNGI RMP BDATA NOTRMP 2 GRSMSCI
PIs Methven, A. S.
TITLE Clavariadelphus and other fungi of the southern Appalachians
YEAR 1984- STATUS ONG
INST UTennessee
CROSSREF LEVEL SYSTEMATICS
CITATIONS

PROJREG FUNGI RMP BDATA NOTRMP 2 GRSMSCI 1
PIs Petersen, R. H.
TITLE Research on fleshy fungi in the southern Appalachian mountains
YEAR 1976- STATUS ONG
INST UTennessee
CROSSREF LEVEL CHECKLIST
CITATIONS Petersen 1978, 1984

PROJREG FUNGI RMP BDATA NOTRMP 2 GRSMSCI
PIs Peterson, A. M.
TITLE Chemistry of Amanita
YEAR 1980-1982 STATUS COMP
INST UTennessee
CROSSREF LEVEL SYSTEMATICS
CITATIONS PhD Dissertation at UT-BOTANY

PROJREG FUNGI RMP BDATA NOTRMP 2 GRSMSCI
PIs Restivo, J. H.
TITLE Monograph of Hydnum for North America
YEAR 1972-1974 STATUS ABAN
INST UTennessee
CROSSREF LEVEL SYSTEMATICS
CITATIONS

PROJREG FUNGI RMP BDATA NOTRMP 2 GRSMSCI
PIs Sturgeon, W.
TITLE General collecting--fungi
YEAR 1984- STATUS ONG
INST PRIVATE
CROSSREF LEVEL CHECKLIST
CITATIONS

PROJREG FUNGI RMP BDATA NOTRMP 2 GRSMSCI
PIs Wolfe, C. B.
TITLE Studies of Tylopilus in the Southeast
YEAR 1975- STATUS
INST UTennessee
CROSSREF LEVEL SYSTEMATICS
CITATIONS PhD Dissertation at UT-BOTANY

PROJREG GAPS RMP BDATA NOTRMP 1 GRSMSCI
PIs Barden, L. S.
TITLE Tree replacement in canopy gaps of hemlock and cove hardwood forest
YEAR 1980-1982 STATUS
INST UNC-Charlotte
CROSSREF GENVEG LEVEL COMMUNITY

PROJREG GAPS RMP BDATA NOTRMP 1 GRSMSCI
PIs Dunne, K.
TITLE Influence of tree gaps on understory diversity in virgin hemlock forests
YEAR 1981-1983 STATUS PREP
INST Rutgers
CROSSREF GENVEG LEVEL COMMUNITY
CITATIONS

PROJREG GAPS RMP BDATA NOTRMP 2 GRSMSCI
PIs Fox, P. J.
TITLE Alternation and coexistence of tree species
YEAR 1976-1977 STATUS COMP
INST UWyoming
CROSSREF GENVEG,GAPS LEVEL COMMUNITY
CITATIONS Fox 1977, Culver 1981

PROJREG GAPS RMP BDATA NOTRMP 1 GRSMSCI
PIs Runkle, J.
TITLE Gap phase succession in cove forests
YEAR 1976- STATUS ONG
INST Cornell
CROSSREF GENVEG LEVEL COMMUNITY
CITATIONS Runkle 1978, 1981, 1982

PROJREG GAPS RMP BDATA NOTRMP 1 GRSMSCI 1
PIs White, P. S., M. D. MacKenzie, and R. T. Busing
TITLE Gap dynamics in southern Appalachian spruce-fir
YEAR 1982-1984 STATUS COMP
INST NPS-UPL,UTennessee
CROSSREF GENVEG LEVEL COMMUNITY,LANDSCAPE
CITATIONS White et al. 1985, 1987

PROJREG GENDIVER RMP MAB-GEN NOTRMP 2 GRSMSCI
PIs Bunn, C. D.
TITLE Genetic diversity--collection of native Rhododendron seeds
YEAR 1985- STATUS
INST
CROSSREF GRASSYB LEVEL SEED COLLECTION
CITATIONS

PROJREG GENDIVER RMP BDATA NOTRMP 2 GRSMSCI
PIs Cox, R. A.
TITLE Genetic diversity--white pine breeding program
YEAR 1984- STATUS ONG
INST
CROSSREF AIR-VEGP LEVEL POPULATION GENETICS
CITATIONS

PROJREG GENDIVER RMP BDATA NOTRMP 2 GRSMSCI
PIs DeHayes, D. H., and C. E. Waite
TITLE Genetic diversity--yellow birch and Fraser fir
YEAR 1983- STATUS
INST UVermont
CROSSREF GENVEG LEVEL POPULATION GENETICS
CITATIONS

PROJREG GENDIVER RMP 10 NOTRMP 1 GRSMSCI
PIs Galle, F. C.
TITLE Hybridization of native azaleas
YEAR 1953- STATUS
INST Calloway Gard
CROSSREF FLORA,GRASSYB,RARE LEVEL GENETICS
CITATIONS

PROJREG GENDIVER RMP BDATA NOTRMP 2 GRSMSCI
PIs Hebb, R., and L. Newcombe
TITLE General collecting--Joing USSR-American field trip
YEAR 1982-1982 STATUS COMP
INST Carey Arboretum
CROSSREF LEVEL CHECKLIST,SEED COLLECTION
CITATIONS

PROJREG GENDIVER RMP 15 NOTRMP 2 GRSMSCI
PIs Jacobs, B. I., C. R. Werth, and S. J. Guttman
TITLE Electrophoretic study of variation in Abies fraseri
YEAR 1982-1984 STATUS COMP
INST Miami U-Ohio
CROSSREF SPRFIR,FLORA,AIR-SARR,BWA LEVEL SYSTEMATICS,GENETICS
CITATIONS Jacobs et al. 1984

PROJREG GENDIVER RMP 15 NOTRMP 2 GRSMSCI
PIs Lambert, H. L., P. P. Hain, W. H. Hoffard, and F. Arthur
TITLE Evaluation of possible geographic variation in susceptibility of Fraser fir to balsam woolly aphid
YEAR 1981- STATUS
INST USDA,NCState
CROSSREF FLORA,GENVEG,BWA LEVEL GENETICS,PHYSIOLOGICAL
CITATIONS

PROJREG GENDIVER RMP MAB-GEN NOTRMP 2 GRSMSCI
PIs Maslona, M. D.
TITLE Genetic diversity--seed collections for germplasm distribution
YEAR 1985- STATUS ONG
INST USDA-National Arboretum
CROSSREF LEVEL SEED COLLECTION
CITATIONS

PROJREG GENDIVER RMP MAB-GEN NOTRMP 2 GRSMSCI
PIs McAbee, J.
TITLE Genetic diversity--native ornamental production from seed
YEAR 1982- STATUS
INST NCState
CROSSREF LEVEL SEED COLLECTION
CITATIONS

PROJREG GENDIVER RMP BDATA NOTRMP 2 GRSMSCI
PIs Parks, C.
TITLE Hybridization and variation in Betula lenta and B. lutea
YEAR 1974- STATUS
INST UNC-Chapel Hill
CROSSREF GENVEG LEVEL POPULATION GENETICS

PROJREG GENDIVER RMP BDATA NOTRMP 2 GRSMSCI
PIs Pritts, M., and J. Hancock
TITLE Ecogenetics of Vaccinium in North America
YEAR - STATUS
INST Michigan State
CROSSREF GENVEG LEVEL POPULATION GENETICS
CITATIONS

PROJREG GENDIVER RMP MAB-GEN NOTRMP 2 GRSMSCI
PIs Simmons, J., and J. Elsley
TITLE Genetic diversity--seed collections for international distribution
YEAR 1981-1981 STATUS COMP
INST Kew Gardens,Missouri Bot Garden
CROSSREF LEVEL SEED COLLECTION
CITATIONS

PROJREG GENDIVER RMP MAB-GEN NOTRMP 2 GRSMSCI
PIs Spjut, R., J. Duke, and C. Edson
TITLE Antitumor screening of bryophytes and lichens
YEAR 1980- STATUS
INST USDA-Beltsville,Purdue,VPI
CROSSREF BRYOPHYT,LICHENS LEVEL GENETIC DIVERSITY
CITATIONS

PROJREG GENDIVER RMP 15 NOTRMP 2 GRSMSCI
PIs Thor, E., and P. E. Barnett
TITLE Variations in balsam monoterpenes and wood properties in Abies
YEAR 1967- STATUS
INST UTennessee
CROSSREF FLORA,BWA LEVEL GENETIC VARIATION
CITATIONS Thor and Barnett 1974

PROJREG GENDIVER RMP 10 NOTRMP 1 GRSMSCI
PIs Towe, L. D., J. D. Fittillo, J. D., and H. Burdette
TITLE Genetic diversity--propagation of hybrid azaleas
YEAR 1976- STATUS
INST WCarolina,Walhalla,Clemson
CROSSREF FLORA,GRASSYB,RARE LEVEL GENETICS,SYSTEMATICS
CITATIONS

PROJREG GENDIVER RMP 15 NOTRMP 2 GRSMSCI
PIs Weber, J. H.
TITLE Natural variation in Fraser fir
YEAR 1975- STATUS
INST NCState
CROSSREF GENVEG,BWA LEVEL POPULATION GENETICS
CITATIONS Li 1985

PROJREG GENDIVER RMP 15 NOTRMP 2 GRSMSCI
PIs Whitfield, F. E.
TITLE Fraser fir provenance
YEAR 1975- STATUS
INST NCState
CROSSREF FLORA,SPRFIR,AIR-SARR,GENVEG,BWA LEVEL POPULATION GENETICS
CITATIONS

PROJREG GENERAL RMP 07.4.B.1 GRSMSCI 1
PIs Berg, D.
TITLE Hazard tree assessment and monitoring program
YEAR 1983- STATUS ONG
INST NPS-RM
CROSSREF GENVEG LEVEL POPULATION
CITATIONS

PROJREG GENERAL RMP BDATA NOTRMP 1 GRSMSCI 1
PIs Bratton, S. P., I. Owen, and P. S. White
TITLE A survey of botanical information needs in Southeast Region National Parks
YEAR 1980-1981 STATUS COMP
INST NPS-UPL
CROSSREF BIBLIOG LEVEL GEMERAL
CITATIONS Bratton et al. 1982

PROJREG GENERAL RMP 13 NOTRMP 1 GRSMSCI 1
PIs Bratton, S. P., R. C. Mathews, Jr., and P. S. White
TITLE Impacts of an agricultural area within a natural area
YEAR 1977-1979 STATUS COMP
INST NPS-UPL
CROSSREF GENVEG LEVEL LANDSCAPE
CITATIONS Bratton et al. 1980

PROJREG GENERAL RMP 26 NOTRMP 1 GRSMSCI 1
PIs Dale, V., R. Gardner, and P. S. White
TITLE An ecological information system for GRSM
YEAR 1985- STATUS ONG
INST ORNL
CROSSREF GIS LEVEL LANDSCAPE
CITATIONS

PROJREG GENERAL RMP BDATA NOTRMP 2 GRSMSCI
PIs DeSelm, H. R., and G. M. Clark
TITLE Potential natural landmarks of the Appalachian ranges natural region of the eastern United States
YEAR 1978-1983 STATUS COMP
INST UTennessee
CROSSREF GENVEG LEVEL COMMUNITY
CITATIONS DeSelm and Clark 1983

PROJREG GENERAL RMP 25 NOTRMP 1 GRSMSCI 1
PIs Larson, G. L.
TITLE Ecology of Gum Swamp
YEAR 1978- STATUS ONG
INST NPS-UPL
CROSSREF GENVEG LEVEL COMMUNITY
CITATIONS

PROJREG GENERAL RMP BDATA NOTRMP 1 GRSMSCI 1
PIs Mack, A., S. P. Bratton, W. Gregg, and P. S. White
TITLE Patterns of scientific research in National Park Service Biosphere Reserves
YEAR 1980-1981 STATUS COMP
INST NPS-UPL
CROSSREF PERMPLOT,BIBLIOG,MAP LEVEL GENERAL

PROJREG GENERAL RMP BDATA NOTRMP 1 GRSMSCI 1
PIs Peine, J. D., C. Pyle, and P. S. White
TITLE Environmental monitoring and baseline data management strategies and the focus of future research in GRSM
YEAR 1982-1985 STATUS COMP
INST NPS-UPL
CROSSREF LEVEL GENERAL
CITATIONS Peine et al. 1985

PROJREG GENERAL RMP 13 NOTRMP 1 GRSMSCI 1
PIs White, P. S.
TITLE Biological assessments
YEAR 1978- STATUS ONG
INST NPS-UPL,NPS-CPSU
CROSSREF RARE,GENVEG LEVEL COMMUNITY,POPULATION
CITATIONS

PROJREG GENERAL RMP 01 NOTRMP 1 GRSMSCI 1
PIs White, P. S., D. G. Silsbee, and C. Eagar
TITLE Air quality related research in GRSM--a project register
YEAR 1985- STATUS ONG
INST NPS-UPL,NPS-CPSU
CROSSREF BIBLIOG,AIR-VEGP,AIR-VEGC,AIR-VEGT LEVEL GENERAL
CITATIONS White et al. 1985

PROJREG GENVEG-A RMP BDATA NOTRMP 1 GRSMSCI
PIs Baranski, M. J.
TITLE Problems in the development and interpretation of plant species distributions as demonstrated by white oak
YEAR 1975- STATUS
INST Catawba College
CROSSREF LEVEL POPULATION,COMMUNITY
CITATIONS Baranski 1975

PROJREG GENVEG-A RMP BDATA NOTRMP 1 GRSMSCI
PIs Baranski, M. J.
TITLE Taxonomy and ecology of red oak populations in the southern Appalachians
YEAR 1976- STATUS
INST Catawba Coll
CROSSREF FLORA LEVEL SYSTEMATICS,COMMUNITY,POPULATI
CITATIONS

PROJREG GENVEG-A RMP BDATA NOTRMP 2 GRSMSCI
PIs Durr, P. C.
TITLE Methods of regeneration in mountain silverbell
YEAR 1981- STATUS
INST UTennessee
CROSSREF LEVEL POPULATION
CITATIONS

PROJREG GENVEG-A RMP BDATA NOTRMP 2 GRSMSCI
PIs Fritts, H. C.
TITLE Reconstruction of past climatic variability by tree rings
YEAR 1972- STATUS COMP
INST UArizona
CROSSREF AIR-VEGT,AIR-SARR,SFRFIR LEVEL PHYSIOLOGICAL
CITATIONS Fritts 1976

PROJREG GENVEG-A RMP BDATA NOTRMP 2 GRSMSCI
PIs Kavanagh, K.
TITLE Population ecology of Liriodendron tulipifera
YEAR 1983- STATUS
INST UToronto
CROSSREF LEVEL POPULATION
CITATIONS

PROJREG GENVEG-A RMP BDATA NOTRMP 2 GRSMSCI
PIs Lazar, D.
TITLE The role of mycorrhizae in the establishment of eastern hemlock
YEAR 1978-1978 STATUS
INST NCState
CROSSREF FUNGI LEVEL POPULATION
CITATIONS

PROJREG GENVEG-A RMP BDATA NOTRMP 2 GRSMSCI
PIs Natella, D. W.
TITLE Elevational effects on Agave virginica
YEAR 1972-1973 STATUS COMP
INST UTennessee
CROSSREF FLORA LEVEL PHYSIOLOGICAL
CITATIONS Natella 1973

PROJREG GENVEG-A RMP BDATA NOTRMP 2 GRSMSCI
PIs Wolfe, C. D., and J. D. Pittillo
TITLE Distribution of river birch, Betula nigra, in western North Carolina
YEAR 1975-1977 STATUS COMP
INST WCarolina
CROSSREF FLORA LEVEL POPULATION
CITATIONS Wolfe and Pittillo 1977

PROJREG GENVEG-C RMP BDATA NOTRMP 2 GRSMSCI
PIs Adams, H. C.
TITLE Structure and relationships of plant communities in GRSM
YEAR 1975- STATUS
INST Dabney Lancaster Comm Coll
CROSSREF LEVEL COMMUNITY
CITATIONS

PROJREG GENVEG-C RMP BDATA NOTRMP 1 GRSMSCI 1
PIs Bratton, S. P.
TITLE The structure and diversity of herbaceous understory communities in temperate deciduous forest
YEAR 1970-1975 STATUS COMP
INST Cornell
CROSSREF HOGS LEVEL COMMUNITY
CITATIONS Bratton 1975, 1975, 1976

PROJREG GENVEG-C RMP BDATA NOTRMP 1 GRSMSCI 1
PIs Callaway, R.
TITLE Permanent plots: prediction of woody volume increment in classified stands in the western GRSM
YEAR 1981-1983 STATUS COMP
INST UTennessee,NPS-UPL
CROSSREF PERMPLOT LEVEL COMMUNITY

PROJREG GENVEG-C RMP BDATA NOTRMP 1 GRSMSCI
PIs Clebsch, E. E. C.
TITLE Ecological studies in GRSM
YEAR 1980- STATUS
INST UTennessee
CROSSREF LEVEL COMMUNITY
CITATIONS

PROJREG GENVEG-C RMP BDATA NOTRMP 1 GRSMSCI
PIs DeLapp, J., and T. Wentworth
TITLE Proposed Research Natural Areas in the southern Appalachian Mountains
YEAR 1976-1977 STATUS COMP
INST NCSU
CROSSREF LEVEL COMMUNITY
CITATIONS DeLapp and Wentworth 1977

PROJREG GENVEG-C RMP BDATA NOTRMP 1 GRSMSCI
PIs DeSelm, H. R.
TITLE Themis vegetation study
YEAR 1969-1973 STATUS COMP
INST UTennessee
CROSSREF VEGMAP,SPRFIR,AIR-SARR LEVEL COMMUNITY
CITATIONS DeSelm and Taylor 1972; Golden 1974, 1981

PROJREG GENVEG-C RMP BDATA NOTRMP 1 GRSMSCI
PIs DeYoung, H. R.
TITLE The white pine-hardwood vegetation types of GRSM
YEAR 1977-1979 STATUS COMP
INST UTennessee
CROSSREF AIR-VEGP LEVEL COMMUNITY
CITATIONS DeYoung 1979

PROJREG GENVEG-C RMP BDATA NOTRMP 2 GRSMSCI
PIs Dickenson, H. F.
TITLE Mineral nutrition of heath bald plants
YEAR 1972- STATUS
INST CARSON NEWMAN
CROSSREF ECOSYST LEVEL PHYSIOLOGY
CITATIONS

PROJREG GENVEG-C RMP BDATA NOTRMP 2 GRSMSCI
PIs Dunwoody, D. A.
TITLE Succession on the Ekaneetlee blowdown
YEAR -1977 STATUS COMP
INST Maryville Coll
CROSSREF LEVEL COMMUNITY
CITATIONS Dunwoody 1977

PROJREG GENVEG-C RMP BDATA NOTRMP 1 GRSMSCI
PIs Eller, G.
TITLE Vegetation analysis
YEAR 1974- STATUS COMP
INST WCarolina
CROSSREF BIBLIOG LEVEL COMMUNITY
CITATIONS

PROJREG GENVEG-C RMP BDATA NOTRMP 1 GRSMSCI 1
PIs Feldkamp, S.
TITLE Revegetation of upper elevation debris slide scars on Mount LeConte in GRSM
YEAR 1979-1984 STATUS COMP
INST UTennessee,NPS-UPL
CROSSREF RARE LEVEL COMMUNITY
CITATIONS Feldkamp 1984

PROJREG GENVEG-C RMP BDATA NOTRMP 1 GRSMSCI
PIs Fuller, R. D.
TITLE The maintenance and origin of the high elevation beech gaps in the GRSM
YEAR 1976-1977 STATUS COMP
INST UTennessee
CROSSREF HOGS LEVEL COMMUNITY
CITATIONS Fuller 1977

PROJREG GENVEG-C RMP BDATA NOTRMP 1 GRSMSCI
PIs Gant, R. E.
TITLE The role of allelopathic interference in the maintenance of southern Appalachian heath balds
YEAR 1977-1978 STATUS COMP
INST UTennessee
CROSSREF LEVEL COMMUNITY,POPULATION
CITATIONS Gant 1978

PROJREG GENVEG-C RMP BDATA NOTRMP 2 GRSMSCI
PIs Givnish, T.
TITLE Structure of herbaceous plant communities
YEAR 1981- STATUS ONG
INST UWisconsin
CROSSREF LEVEL COMMUNITY,POPULATION
CITATIONS

PROJREG GENVEG-C RMP BDATA NOTRMP 1 GRSMSCI
PIs Golden, M. S.
TITLE Forest vegetation and site relationships in the central portion of GRSM
YEAR 1971-1974 STATUS COMP
INST UTennessee
CROSSREF LEVEL COMMUNITY
CITATIONS Golden 1974, 1981

PROJREG GENVEG-C RMP BDATA NOTRMP 2 GRSMSCI
PIs Hicks, D.
TITLE Organization of herbaceous communities
YEAR 1975-1978 STATUS COMP
INST Cornell
CROSSREF LEVEL COMMUNITY,POPULATION
CITATIONS Hicks 1978, 1980, 1982

PROJREG GENVEG-C RMP 26.4.C.1 GRSMSCI 1
PIs MacKenzie, M. D., and P. S. White
TITLE Analysis of Miller vegetation plot data
YEAR 1978- STATUS PREP
INST NPS-UPL,NPS-CPSU
CROSSREF VEGMAP,MODEL LEVEL COMMUNITY,LANDSCAPE

PROJREG GENVEG-C RMP BDATA NOTRMP 2 GRSMSCI
PIs Montgomery, L.
TITLE Allelopathic studies in Rhododendron minus
YEAR 1982- STATUS
INST Maryville Coll
CROSSREF LEVEL PHYSIOLOGICAL,COMMUNITY
CITATIONS

PROJREG GENVEG-C RMP BDATA NOTRMP 1 GRSMSCI
PIs Pavlovic, N. B.
TITLE Observations concerning seed rain and seed banks in a spruce-fir stand and a gray beech community
YEAR 1980-1981 STATUS COMP
INST UTennessee
CROSSREF HOGS LEVEL COMMUNITY
CITATIONS Pavlovic 1981

PROJREG GENVEG-C RMP BDATA NOTRMP 1 GRSMSCI
PIs Pittillo, J. D.
TITLE A comparison of spruce-fir forest south of Virginia
YEAR 1982-1984 STATUS COMP
INST WCarolina
CROSSREF LEVEL COMMUNITY,LANDSCAPE
CITATIONS Pittillo 1984

PROJREG GENVEG-C RMP BDATA NOTRMP 1 GRSMSCI
PIs Pittillo, J. D., and G. Smathers
TITLE Comparison of vegetation in GRSM and the Balsam Mountains
YEAR 1978-1982 STATUS COMP
INST WCarolina,NPS-CPSU-WC
CROSSREF SPRFIR LEVEL COMMUNITY,LANDSCAPE
CITATIONS Pittillo and Smathers 1979, 1981; Pittillo 1984

PROJREG GENVEG-C RMP 26 NOTRMP 1 GRSMSCI 1
PIs Pyle, C.
TITLE Permanent plots: prediction of forest growth on disturbed sites in GRSM
YEAR 1985- STATUS ONG
INST UTennessee
CROSSREF PERMPLOT LEVEL POPULATION,COMMUNITY
CITATIONS

PROJREG GENVEG-C RMP BDATA NOTRMP 1 GRSMSCI
PIs Rheinhardt, R. D.
TITLE Comparative study of subalpine forests in the Balsam Mts of southwest Virginia and GRSM
YEAR 1981-1984 STATUS COMP
INST William and Mary
CROSSREF AIP-SARR LEVEL COMMUNITY
CITATIONS Rheinhart 1984

PROJREG GENVEG-C RMP BDATA NOTRMI 2 GRSMSCI
PIs Sain, R. E., and K. E. Blum
TITLE Seedling production in the high elevation beech (Fagus grandifolia Ehrh.) forests of GRSM
YEAR 1979-1981 STATUS COMP
INST
CROSSREF HOGS LEVEL COMMUNITY,POPULATION
CITATIONS Sain and Blum 1981

PROJREG GENVEG-C RMP BDATA NOTRMP 1 GRSMSCI
PIs Saunders, P. R.
TITLE An analysis of the understory site type concept, growth, and disturbance spruce-fir forests
YEAR 1976- STATUS
INST Duke
CROSSREF BWA,AIR-VEGC,DISTHIST,AIR-SARR LEVEL COMMUNITY
CITATIONS Saunders 1979

PROJREG GENVEG-C RMP BDATA NOTRMP 2 GRSMSCI
PIs Schwarzkopf, S. K.
TITLE Comparative vegetation analysis of five spruce-fir areas in the southern Appalachians
YEAR 1973-1974 STATUS COMP
INST Furman
CROSSREF GENVEG,AIR-SARR,BWA LEVEL COMMUNITY
CITATIONS Schwarzkopf 1974

PROJREG GENVEG-C RMP 26 NOTRMP 1 GRSMSCI
PIs Walker, G. L.
TITLE A comparative vegetational analysis of cove hardwoods
YEAR 1977-1978 STATUS COMP
INST WCarolina
CROSSREF PERMPLOT LEVEL COMMUNITY
CITATIONS Walker 1978

PROJREG GENVEG-C RMP BDATA NOTRMP 2 GRSMSCI
PIs Weaver, G. T.
TITLE General vegetation patterns--reconaissance
YEAR 1976-1976 STATUS ABAN
INST So Illinois U
CROSSREF LEVEL COMMUNITY
CITATIONS

PROJREG GENVEG-C RMP BDATA NOTRMP 2 GRSMSCI
PIs West, D. C.
TITLE Role of terrestrial ecosystems in the global carbon cycle
YEAR 1978- STATUS
INST ORNL
CROSSREF VEGMAP LEVEL LANDSCAPE
CITATIONS

PROJREG GIS RMP 26.4.C.4 GRSMSCI 1
PIs Carter, J., P. S. White, and M. D. MacKenzie
TITLE GRSM cartographic data base
YEAR 1982- STATUS ONG
INST UTennessee,NPS-CPSU,NPS-DSC
CROSSREF VEGMAP LEVEL LANDSCAPE
CITATIONS White and MacKenzie, In press; Carter, In press

PROJREG GIS RMP 26 NOTRMP 1 GRSMSCI 1
PIs Su, M. Y.
TITLE Resource basic inventory for Great Smoky Mountains National Park
YEAR -1975 STATUS COMP
INST NASA
CROSSREF GENVEG,VEGMAP LEVEL LANDSCAPE,GENERAL

PROJREG GRASSYB RMP 10 NCTRMP 1 GRSMSCI
PIs Clebsch, E. E. C.
TITLE Ecological study of Gregory Bald, Spence Field, and Andrews Bald
YEAR 1966- STATUS ONG
INST UTennessee
CROSSREF PERMPLOT LEVEL COMMUNITY
CITATIONS

PROJREG GRASSYB RMP 10 NOTRMP 1 GRSMSCI
PIs Kellner, C. V.
TITLE Are pollinators exerting selection pressure on the azalea hybrids on Gregory Bald?
YEAR 1976-1978 STATUS COMP
INST UTennessee
CROSSREF RARE LEVEL POLLINATION BIOLOGY
CITATIONS Kellner 1978

PROJREG GRASSYB RMP 10 NOTRMP 1 GRSMSCI 1
PIs Lindsay, M. M., and S. P. Bratton
TITLE History, succession, and management of grassy balds
YEAR 1975-1977 STATUS COMP
INST Cornell,NPS-UPL
CROSSREF GENVEG,DISTHIST LEVEL COMMUNITY
CITATIONS Lindsay 1976, 1977, 1978; Lindsay and Bratton 1979, 1979, 1980

PROJREG GRASSYB RMP 10 NOTRMP 1 GRSMSCI 1
PIs Ramseur, G. S.
TITLE Secondary succession in the spruce-fir forests of GRSM
YEAR 1975-1976 STATUS COMP
INST USouth
CROSSREF GENVEG,DISTHIST,SPRFIR LEVEL COMMUNITY
CITATIONS Ramseur 1976

PROJREG GRASSYB RMP 10 NOTRMP 1 GRSMSCI 1
PIs White, P. S.
TITLE Vascular plants of the grassy balds
YEAR 1979-1982 STATUS PREP
INST NPS-UPL,NPS-CPSU
CROSSREF FLORA,RARE LEVEL POPULATION,CHECKLIST
CITATIONS Stratton and White 1982

PROJREG GRASSYB RMP 10 NOTRMP 1 GRSMSCI 1
PIs White, P. S.
TITLE Components of succession on grassy balds
YEAR 1982- STATUS PREP
INST NPS-UPL,NPS-CPSU
CROSSREF GENVEG LEVEL COMMUNITY
CITATIONS

PROJREG GYPSY RMP 14 NOTRMP 1 GRSMSCI 1
PIs Berg, D.
TITLE Gypsy moth monitoring using pheromone traps
YEAR 1981- STATUS ONG
INST NPS-RM
CROSSREF LEVEL POPULATION
CITATIONS

PROJREG GYPSY RMP 14 NOTRMP 1 GRSMSCI 1
PIs White, P. S.
TITLE Gypsy moth vulnerability and susceptibility ratings
YEAR 1983-1984 STATUS PREP
INST NPS-UPL
CROSSREF LEVEL COMMUNITY
CITATIONS

PROJREG HOGS RMP 24 NOTRMP 1 GRSMSCI
PIs Belden, R. C.
TITLE European wild hog rooting and wallowing in GRSM
YEAR -1976 STATUS COMP
INST UTennessee
CROSSREF GENVEG LEVEL COMMUNITY
CITATIONS Belden 1972; Belden and Pelton 1975, 1976

PROJREG HOGS RMP 24 NOTRMP 1 GRSMSCI
PIs Benda, R.
TITLE A field guide to European wild hog impact in GRSM, with an assessment of seasonal rooting habits
YEAR 1983-1984 STATUS COMP
INST UTennessee
CROSSREF GENVEG LEVEL COMMUNITY,POPULATION
CITATIONS Benda 1984

PROJREG HOGS RMP 24 NOTRMP 1 GRSMSCI 1
PIs Bratton, S. P.
TITLE The effect of European wild boar on high elevation vernal flora and beech forests of GRSM
YEAR 1973-1975 STATUS COMP
INST Cornell
CROSSREF GENVEG LEVEL COMMUNITY
CITATIONS Bratton 1974, 1975

PROJREG HOGS RMP 24 NOTRMP 1 GRSMSCI 1
PIs Bratton, S. P.
TITLE Hog exclosure study: first project
YEAR 1976-1979 STATUS COMP
INST NPS-UPL
CROSSREF GENVEG LEVEL COMMUNITY
CITATIONS Bratton et al. 1981, 1982

PROJREG HOGS RMP 24.4.B.1 GRSMSCI 1
PIs Bratton, S. P., P. J. Singer, M. E. Harmon, and P. S. White
TITLE Permanent plots: rooting impacts of the European wild boar during a year of mast failure
YEAR 1978-1979 STATUS COMP
INST NPS-UPL
CROSSREF GENVEG LEVEL COMMUNITY
CITATIONS Bratton et al. 1979, 1982

PROJREG HOGS RMP 24.4.C.1 GPSMSCI 1
PIs Eagar, C.
TITLE Development of a European wild hog rooting damange monitoring program
YEAR 1984-1986 STATUS PREP
INST NPS-UPL
CROSSREF GENVEG LEVEL COMMUNITY

PROJREG HOGS RMP 24 NOTRMP 1 GRSMSCI 1
PIs Howe, T. D., F. J. Singer, and B. B. Ackerman
TITLE High elevation forage relationships of European wild boar invading GRSM
YEAR 1977-1979 STATUS COMP
INST NPS-UPL
CROSSREF GENVEG LEVEL POPULATION,COMMUNITY
CITATIONS Howe et al. 1979, 1981

PROJREG HOGS RMP 24 NOTRMP 1 GRSMSCI 1
PIs Howe, T., and S. P. Bratton
TITLE Winter rooting activity of the European wild boar in GRSM
YEAR 1975-1976 STATUS COMP
INST NPS-UPL
CROSSREF GENVEG LEVEL COMMUNITY,ENVIRONMENTAL
CITATIONS Howe and Bratton 1976

PROJREG HOGS RMP 24 NOTRMP 1 GRSMSCI 1
PIs Huff, M. H.
TITLE The effect of European wild boar (Sus scrofa) on the woody vegetation of gray beech forest in GRSM
YEAR 1976-1977 STATUS COMP
INST Duke
CROSSREF GENVEG LEVEL COMMUNITY,POPULATION
CITATIONS Huff 1977, 1981

PROJREG HOGS RMP 24 NOTRMP 1 GRSMSCI 1
PIs Lacki, M. J.
TITLE Effect of wild boar on tree growth: an alternative hypothesis
YEAR 1982-1985 STATUS COMP
INST NC State
CROSSREF GENVEG LEVEL PHYSIOLOGICAL
CITATIONS Lacki 1984, 1985

PROJREG HOGS RMP 24 NOTRMP 1 GRSMSCI 1
PIs Nicholas, N. S., and P. S. White
TITLE The GRSM hard mast survey: an evaluation
YEAR 1983-1984 STATUS COMP
INST NPS-UPL
CROSSREF LEVEL POPULATION
CITATIONS Nicholas and White 1984

PROJREG HOGS RMP 24 NOTRMP 1 GRSMSCI
PIs Scott, C. D.
TITLE Seasonal food habits of the European wild hog in GRSM
YEAR -1975 STATUS COMP
INST UTennessee
CROSSREF LEVEL POPULATION
CITATIONS Scott 1973; Scott and Pelton 1975

PROJREG HOGS RMP 24 NOTRMP 1 GRSMSCI 1
PIs Singer, F. J., B. Ackerman, and M. E. Harmon
TITLE Seasonal food habits of the European wild boar in GRSM
YEAR 1977- STATUS
INST NPS-UPL
CROSSREF LEVEL POPULATION
CITATIONS Ackerman et al. 1978; Singer and Ackerman 1981

PROJREG HOGS RMP 24 NOTRMP 1 GRSMSCI 1
PIs Singer, F. J., D. K. Otto, A. R. Tipton, and C. P. Hable
TITLE Home ranges and habitat use of European wild boar
YEAR 1977-1979 STATUS COMP
INST NPS-UPL,VPI
CROSSREF GENVEG LEVEL POPULATION,LANDSCAPE
CITATIONS Singer et al. 1979, 1981; Tipton and Otto 1979

PROJREG HOGS RMP 24 NOTRMP 1 GRSMSCI 1
PIs Singer, F. J., W. T. Swank, and E. E. C. Clebsch
TITLE Some ecosystem responses of wild boar rooting in a deciduous forest
YEAR 1981-1983 STATUS COMP
INST NPS-UPL,USFS-Coweeta,UTennessee
CROSSREF GENVEG,ECOSYST LEVEL COMMUNITY,ECOSYSTEM
CITATIONS Singer et al. 1982, 1984

PROJREG HOGS RMP 24.4.C.4 GRSMSCI 1
PIs White, P. S.
TITLE Hog exclosure study: second project
YEAR 1981- STATUS ONG
INST NPS-UPL,NPS-CPSU
CROSSREF GENVEG,FLORA,RARE LEVEL POPULATION,COMMUNITY
CITATIONS White 1984

PROJREG HOGS RMP 24.4.C.4 GRSMSCI 1
PIs White, P. S.
TITLE Data base on wild hog food items
YEAR 1983-1986 STATUS PREP
INST NPS-UPL,NPS-CPSU
CROSSREF FLORA,RARE LEVEL POPULATION
CITATIONS

PROJREG ISLANDS RMP MAB-ISL NOTRMP 1 GRSMSCI 1
PIs Bratton, S. P., and P. S. White
TITLE The design of nature preserves: considerations of boundary placement and insularity
YEAR 1981-1984 STATUS COMP
INST NPS-UPL,NPS-CPSU-GA
CROSSREF LEVEL LANDSCAPE,GENERAL
CITATIONS Miller 1985; Miller et al., In press; Miller and White 1986; White et al. 1981

PROJREG LANDSL RMP BDATA NOTRMP 1 GRSMSCI
PIs Ryan, P.
TITLE Debris slide/debris flow events: processes, site factors, and hillslope development
YEAR 1984- STATUS ONG
INST UTennessee
CROSSREF GENVEG LEVEL ENVIRONMENTAL
CITATIONS

PROJREG LANDSL RMP BDATA NOTRMP 2 GRSMSCI
PIs Wilson, G. C.
TITLE Debris avalanche and rainfall in the southern Appalachians
YEAR 1984- STATUS ONG
INST

PROJREG LICHENS RMP BDATA NOTRMP 2 GRSMSCI
PIs Ahmadjian, V.
TITLE Experimental studies of lichen symbiosis
YEAR 1980-1980 STATUS
INST Clark U
CROSSREF GENVEG LEVEL POPULATION,PHYSIOLOGICAL
CITATIONS

PROJREG LICHENS RMP BDATA NOTRMP 2 GRSMSCI
PIs Andrews, L.
TITLE Relationship between microclimate and lichen distribution
YEAR 1981-1981 STATUS COMP
INST Maryville Coll
CROSSREF GENVEG LEVEL COMMUNITY
CITATIONS

PROJREG LICHENS RMP BDATA NOTRMP 2 GRSMSCI
PIs Culberson, W. L.
TITLE Spore cultures and secondary compounds of lichens
YEAR 1984-1984 STATUS COMP
INST Duke
CROSSREF LEVEL POPULATION,PHYSIOLOGY
CITATIONS

PROJREG LICHENS RMP BDATA NOTRMP 2 GRSMSCI
PIs Dey, J. P.
TITLE Fruticose and foliose lichens of the high mountain areas of the southern Appalachians
YEAR 1975-1978 STATUS COMP
INST Duke
CROSSREF SPRFIR,AIR-LICH LEVEL COMMUNITY,CHECKLIST,SYSTEMATIC
CITATIONS Dey 1975, 1978, 1979, 1984

PROJREG LICHENS RMP BDATA NOTRMP 2 GRSMSCI
PIs Malter, J. L.
TITLE Lichens of Quercus and Betula substrata
YEAR 1976-1976 STATUS ABAN
INST UTennessee
CROSSREF GENVEG LEVEL COMMUNITY
CITATIONS

PROJREG LICHENS RMP BDATA NOTRMP 2 GRSMSCI
PIs Pike, J.
TITLE Taxonomy of Hypogymnia
YEAR - STATUS
INST George Mason U
CROSSREF LEVEL SYSTEMATICS
CITATIONS

PROJREG LICHENS RMP BDATA NOTRMP 2 GRSMSCI
PIs Smith, D. K.
TITLE General collecting--lichens
YEAR 1977- STATUS ONG
INST UTennessee
CROSSREF GENVEG LEVEL SYSTEMATICS,CHECKLIST
CITATIONS

PROJREG MODEL RMP 01 NOTRMP 1 GRSMSCI
PIs Busing, R. T.
TITLE Gap and stand dynamics of a southern Appalachian spruce-fir forest
YEAR 1983-1985 STATUS COMP
INST UTennessee
CROSSREF BWA,GENVEG,SPRFIR,AIR-SARR,AIR-VEGP,AIR-VEGC LEVEL COMMUNITY,ECOSYST
CITATIONS Busing 1985

PROJREG MODEL RMP BDATA NOTRMP 1 GRSMSCI
PIs MacKenzie, M. D.
TITLE Modelling vegetation gradients in GRSM
YEAR 1982-1986 STATUS PREP
INST NPS-UPL,UTennessee,ORNL
CROSSREF GENVEG LEVEL COMMUNITY,LANDSCAPE
CITATIONS

PROJREG MODEL RMP BDATA NOTRMP 1 GRSMSCI
PIs Weinstein, D. A.
TITLE Assessing the internally variability in forest nutrient cycles: a new look at forest process comparisons
YEAR 1978-1982 STATUS COMP
INST UTennessee,ORNL
CROSSREF GENVEG LEVEL ECOSYSTEM
CITATIONS Weinstein 1982, Weinstein et al. 1982

PROJREG PALEO RMP BDATA NOTRMP 2 GRSMSCI
PIs Davidson, J. L.
TITLE Paleoecology of Lake-in-the-Woods, Cades Cove
YEAR 1981-1983 STATUS COMP
INST UTennessee
CROSSREF GENVEG,GEOL LEVEL COMMUNITY,LANDSCAPE
CITATIONS Davidson 1983

PROJREG PALEO RMP BDATA NOTRMP 2 GRSMSCI
PIs Torbett, C. A., III
TITLE Geomorphic and soil features at Rocky Top and in Cades Cove
YEAR 1984-1986 STATUS PREP
INST UTennessee
CROSSREF LEVEL ENVIRONMENTAL
CITATIONS

PROJREG PATHOL RMP BDATA NOTRMP 2 GRSMSCI
PIs Baker, A. M.
TITLE Study of two scale insect species in GRSM
YEAR 1981-1981 STATUS COMP
INST Maryville Coll
CROSSREF GENVEG LEVEL PHYSIOLOGICAL
CITATIONS

PROJREG PATHOL RMP BDATA NOTRMP 2 GRSMSCI
PIs Bernard, E. C., and S. D. Mobbs
TITLE Selected plant parasitic nematodes of Tennessee
YEAR 1982- STATUS
INST UTennessee
CROSSREF LEVEL PHYSIOLOGY

PROJREG PATHOL RMP BDATA NOTRMP 2 GRSMSCI
PIs Bruck, R.
TITLE Epidemiology of Phytophthora cinnamomi on Fraser fir
YEAR 1979- STATUS
INST NCState
CROSSREF GENVEG,BWA LEVEL POPULATION
CITATIONS

PROJREG PATHOL RMP BDATA NOTRMP 2 GRSMSCI
PIs Fritz, R. S.
TITLE Growth rates of black locust in relation to defoliation by the locust leaf-mining beetle
YEAR 1981- STATUS 81
INST UMaryland
CROSSREF GENVEG LEVEL PHYSIOLOGICAL
CITATIONS

PROJREG PATHOL RMP 14 NOTRMP 2 GRSMSCI
PIs Lambdin, P. L., K. Watson, and P. Vix
TITLE Scale insects of GRSM
YEAR 1976- STATUS
INST UTennessee
CROSSREF GENVEG LEVEL PHYSIOLOGICAL
CITATIONS

PROJREG PATHOL RMP BDATA NOTRMP 2 GRSMSCI
PIs Seifert, K. A.
TITLE Stilbella acerina on Acer rubrum
YEAR 1984-1984 STATUS COMP
INST Centr. Schimmel. Netherlands
CROSSREF FUNGI LEVEL PHYSIOLOGICAL
CITATIONS

PROJREG PATHOL RMP BDATA NOTRMP 2 GRSMSCI
PIs Williamson, G. W.
TITLE Collection of forest and plant disease specimens
YEAR 1981- STATUS
INST UTennessee
CROSSREF GENVEG LEVEL PHYSIOLOGICAL
CITATIONS

PROJREG PATHOL RMP BDATA NOTRMP 2 GRSMSCI
PIs Windham, M. T.
TITLE Dogwood canker study
YEAR 1986- STATUS ONG
INST UTennessee
CROSSREF GENVEG LEVEL PHYSIOLOGICAL,PATHOLOGICAL
CITATIONS

PROJREG PERMPLOT RMP 14 NOTRMP 1 GRSMSCI 1
PIs Arends, E.
TITLE Permanent plots: vegetation change a half century following the chestnut blight
YEAR 1979-1981 STATUS COMP
INST UTennessee
CROSSREF CHESTNUT,GENVEG LEVEL COMMUNITY
CITATIONS Arends 1981

PROJREG PERMPLOT RMP 26 NCTRMP 1 GRSMSCI 1
PIs Becking, R., and J. S. Olson
TITLE Permanent plots: remeasurement of permanent vegetation plots in GRSM
YEAR 1977-1978 STATUS COMP
INST ORNL
CROSSREF GENVEG LEVEL COMMUNITY,ECOSYSTEM
CITATIONS Becking and Olson 1978

PROJREG PERMPLOT RMP 23 NCTRMP 1 GRSMSCI 1
PIs Bratton, S. P.
TITLE Permanent plots: impact of deer and cattle on the vegetation of Cades Cove
YEAR 1977-1980 STATUS COMP
INST NPS-UPL
CROSSREF GENVEG LEVEL COMMUNITY
CITATIONS Bratton 1979, 1980

PROJREG PERMPLOT RMP 01.4.C.1 GRSMSCI 1
PIs Eagar, C.
TITLE Permanent plots: spruce-fir forest
YEAR 1984-1984 STATUS COMP
INST NPS-UPL
CROSSREF AIR-SARR,GENVEG LEVEL COMMUNITY
CITATIONS

PROJREG PERMPLOT RMP 26 NCTRMP 1 GRSMSCI 1
PIs Harmon, M. E.
TITLE Permanent plots: vegetation of the western section of GRSM
YEAR 1978-1982 STATUS COMP
INST NPS-UPL,UTennessee
CROSSREF GENVEG,FIRE LEVEL COMMUNITY
CITATIONS Harmon 1980

PROJREG PERMPLOT RMP 01.4.C.1 GRSMSCI 1
PIs Nicholas, N. S., and P. S. White
TITLE Permanent plots: biomass distribution in spruce-fir forests
YEAR 1984-1986 STATUS PREP
INST NPS-UPL
CROSSREF GENVEG,AIR-VEGC,AIR-SARR,BWA LEVEL COMMUNITY,ECOSYST
CITATIONS

PROJREG PERMPLOT RMP 26.4.C.1 GRSMSCI 1
PIs White, P. S.
TITLE Permanent vegetation plots: establishment of the network for GRSM and curation of the data set
YEAR 1977- STATUS ONG
INST NPS-UPL,NPS-CPSU
CROSSREF FIRE,RARE,VISIMP,SPRFIR,GENVEG,HCGS,SPECPROT LEVEL COMMUNITY
CITATIONS

PROJREG PERMPLOT RMP 26 NCTRMP 1 GRSMSCI 1
PIs White, P. S.
TITLE Permanent plots: vegetation of western GRSM on logged and unlogged sites
YEAR 1978- STATUS
INST NPS-UPL,NPS-CPSU

PROJREG PERMPLOT RMP 26 NOTRMP 1 GRSMSCI 1
PIs White, P. S., and S. P. Bratton
TITLE Permanent plots: limestone areas
YEAR 1979- STATUS PREP
INST NPS-UPL,NPS-CPSU
CROSSREF GENVEG,SPECPROT,RARE LEVEL COMMUNITY
CITATIONS

PROJREG PERMPLOT RMP 26 NOTRMP 1 GRSMSCI 1
PIs White, P. S., and S. P. Bratton
TITLE Permanent plots: summit of Mt LeConte
YEAR 1979-1980 STATUS PREP
INST NPS-UPL,NPS-CPSU
CROSSREF GENVEG,AIR-SARR LEVEL COMMUNITY
CITATIONS

PROJREG RARE RMP 26 NOTRMP 2 GRSMSCI
PIs Anderson, L. C.
TITLE Life history and ecology of Carex misera and Carex purpurifera
YEAR 1977- STATUS
INST NCState
CROSSREF GENVEG,FLORA LEVEL POPULATION
CITATIONS

PROJREG RARE RMP 26 NOTRMP 1 GRSMSCI 1
PIs Bratton, S. P.
TITLE Rare and endangered plants of GRSM: compilation
YEAR 1977-1981 STATUS COMP
INST NPS-UPL
CROSSREF FLORA LEVEL POPULATION,CHECKLIST
CITATIONS Bratton 1979

PROJREG RARE RMP 26 NOTRMP 1 GRSMSCI 1
PIs Bratton, S. P.
TITLE Effects of poaching on populations of rare plants
YEAR 1981-1983 STATUS COMP
INST NPS-UPL,NPS-CPSU-GA
CROSSREF VISIMP LEVEL POPULATION
CITATIONS Bratton ****

PROJREG RARE RMP 26 NOTRMP 1 GRSMSCI
PIs Collins, L.
TITLE Distribution of selected high elevation species
YEAR 1981- STATUS
INST TVA
CROSSREF LEVEL CHECKLIST,POPULATION
CITATIONS

PROJREG RARE RMP 26 NOTRMP 1 GRSMSCI
PIs Collins, L.
TITLE Rare plants: TVA natural heritage data base
YEAR 1978- STATUS ONG
INST TVA
CROSSREF FLORA LEVEL POPULATION,CHECKLIST
CITATIONS

PROJREG RARE RMP 26 NOTRMP 1 GPSMSCI
PIs Farmer, R. E., Jr.
TITLE Germination of Parnassia asarifolia and other rare plants
YEAR 1975-1979 STATUS COMP
INST TVA
CROSSREF LEVEL POPULATION
CITATIONS Farmer 1980

PROJREG RARE RMP 26 NOTRMP 1 GRSMSCI
PIs Fuller, L.
TITLE General reconaissance--rare and endangered plants
YEAR 1978- STATUS
INST Private
CROSSREF FLORA LEVEL POPULATION,CHECKLIST
CITATIONS

PROJREG RARE RMP 26 NOTRMP 2 GRSMSCI
PIs Johnson, R. H., III
TITLE Distribution and ecology of Cympophyllus fraseri
YEAR 1984- STATUS ONG
INST WCarolina
CROSSREF FLORA,GENVEG LEVEL POPULATION
CITATIONS

PROJREG RARE RMP 26 NOTRMP 2 GRSMSCI
PIs Klostermeyer, E.
TITLE Pollinators of selected rare plants
YEAR 1982-1982 STATUS COMP
INST Washington State
CROSSREF LEVEL POLLINATION BIOLOGY
CITATIONS

PROJREG RARE RMP 26 NOTRMP 1 GRSMSCI
PIs Kral, R.
TITLE Rare plants: southern forests
YEAR -1983 STATUS COMP
INST Vanderbilt
CROSSREF FLORA LEVEL POPULATION,CHECKLIST
CITATIONS Kral 1983

PROJREG RARE RMP 26 NOTRMP 1 GRSMSCI
PIs Massey, J.
TITLE Rare plants: mountains of North Carolina
YEAR 1978-1983 STATUS COMP
INST UNC-Chapel Hill
CROSSREF FLORA LEVEL POPULATION,CHECKLIST
CITATIONS Massey et al. 1983

PROJREG RARE RMP 26 NOTRMP 1 GRSMSCI
PIs Moore, J.
TITLE Rare plants: North Carolina natural heritage data base
YEAR - STATUS ONG
INST State of NC
CROSSREF FLORA LEVEL POPULATION,CHECKLIST

PROJREG RARE RMP 26 NOTRMP 2 GRSMSCI
PIs Morgan, S. W.
TITLE Species biology of Geum radiatum Michaux
YEAR - STATUS
INST UNC-Chapel Hill
CROSSREF FLORA LEVEL POPULATION
CITATIONS Morgan 1980

PROJREG RARE RMP NOTRMP 1 GRSMSCI 1
PIs Pittillo, J. D., and T. E. Govus
TITLE Rare plants and habitats of the Blue Ridge Parkway
YEAR -1978 STATUS COMP
INST WCarolina
CROSSREF FLORA,GENVEG LEVEL CHECKIIST,POPULATION
CITATIONS Pittillo and Govus 1978

PROJREG RAPE RMP 26 NOTRMP 1 GRSMSCI 1
PIs Pounds, L., and T. Patrick
TITLE Rare plants of Cumberland Gap National Historical Park
YEAR 1983- STATUS PREP
INST UTennessee
CROSSREF FLORA LEVEL CHECKLIST,POPULATION
CITATIONS

PROJREG BARE RMP 26 NOTRMP 1 GRSMSCI
PIs Somers, P.
TITLE Rare plants: Tennessee natural heritage data base
YEAR - STATUS ONG
INST State of Tennessee
CROSSREF FLORA LEVEL POPULATION,CHECKLIST
CITATIONS

PROJREG RARE RMP 26 NOTRMP 1 GRSMSCI
PIs Sutter, R.
TITLE Rare plants: An atlas for North Carolina
YEAR 1978-1986 STATUS PREP
INST State of NC
CROSSREF FLORA LEVEL POPULATION,CHECKLIST
CITATIONS Sutter and McCarthy, in press

PROJREG RARE RMP 26.4.C.7 GRSMSCI 1
PIs White, P. S.
TITLE Rare and endangered plants of GRSM: survey and monitoring
YEAR 1979- STATUS ONG
INST NPS-UPL,NPS-CPSU
CROSSREF PERMPLOT LEVEL POPULATION
CITATIONS White 1980,1981,1981,1982; White and Bratton 1981; Bratton and White 1980, 1981

PROJREG RARE PMP 26 NOTRMP 1 GRSMSCI 1
PIs White, P. S.
TITLE Earthwatch studies: Cacalia, Cladrastis
YEAR 1981- STATUS PREP
INST NPS-UPL,NPS-CPSU
CROSSREF PERMPLOT,SPRFIR,FLORA,AIR-VEGP,GRASSYB LEVEL POPULATION
CITATIONS

PROJREG RARE RMP 26 NOTRMP 1 GRSMSCI 1
PIs White, P. S.
TITLE Earthwatch studies: azaleas, grassy balds flora, and succession
YEAR 1982- STATUS PREP
INST NPS-UPL,NPS-CPSU
CROSSREF GENVEG,RARE LEVEL POPULATION,COMMUNITY
CITATIONS

PROJREG ROADS RMP 13 NOTRMP 1 GRSMSCI 1
PIs Anderson, W. H.
TITLE Dwarfing and chlorosis of Rhododendron
YEAR 1974-1975 STATUS COMP
INST NPS-BStL
CROSSREF LEVEL PHYSIOLOGICAL
CITATIONS

PROJREG SOILS RMP BDATA NOTRMP 1 GRSMSCI
PIs Lietzke, D. A.
TITLE Investigations of high elevation soils
YEAR 1981- STATUS ONG
INST UTennessee
CROSSREF AIR-STR,AIR-VEGC,AIR-ECOS LEVEL ENVIRONMENTAL
CITATIONS

PROJREG SOILS RMP BDATA NOTRMP 1 GRSMSCI
PIs McGuire, G. A.
TITLE Spruce-fir soils in the southern Appalachians
YEAR 1984- STATUS COMP
INST UTennessee
CROSSREF BWA,AIR-VEGC,AIR-TRAC,AIR-SARR LEVEL ENVIRONMENTAL
CITATIONS McGuire 1983

PROJREG SOILS RMP BDATA NOTRMP 1 GRSMSCI
PIs Newton, D.
TITLE Soils mapping for acid deposition sensitivity of selected watersheds
YEAR 1985- STATUS ONG
INST SCS
CROSSREF AIR-ECOS LEVEL ENVIRONMENTAL
CITATIONS

PROJREG SOILS RMP BDATA NOTRMP 1 GRSMSCI 1
PIs Sherrill, M. L., and C. McCowen
TITLE The 1984 GRSM soil survey
YEAR 1984-1985 STATUS COMP
INST SCS
CROSSREF AIR-TRAC,AIR-SARR LEVEL ENVIRONMENTAL
CITATIONS Sherrill and McCowen 1984

PROJREG SOPINEBE RMP 11 NOTRMP 1 GRSMSCI
PIs Kuykendall, N.
TITLE Composition and structure of replacement forest stands following southern pine beetle infestations
YEAR 1976-1978 STATUS COMP
INST UTennessee
CROSSREF GENVEG,FIRE LEVEL COMMUNITY

PROJREG SOPINEBE RMP BDATA NOTRMP 2 GRSMSCI
PIs Whitley, A. M.
TITLE Southern pine beetle infestations in GRSM
YEAR -1977 STATUS COMP
INST Maryville Coll
CROSSREF GENVEG,FIRE LEVEL COMMUNITY
CITATIONS Whitley 1977

PROJREG SPECPROT RMP 25.4.B.1 GRSMSCI 1
PIs White, P. S.
TITLE Special protection areas: characterization and analysis
YEAR 1977- STATUS ONG
INST NPS-UPL,NPS-CPSU
CROSSREF GENVEG,FLORA LEVEL COMMUNITY,CHECKLIST
CITATIONS

PROJREG VEGMAP RMP 26 NOTRMP 2 GRSMSCI
PIs Ambrosia, V.
TITLE Terrain cover and shadow discrimination from LANDSAT data of GRSM
YEAR 1978-1980 STATUS COMP
INST UTennessee
CROSSREF SPRFIR,AIR-SARR LEVEL LANDSCAPE
CITATIONS Ambrosia 1980

PROJREG VEGMAP RMP 26 NOTRMP 1 GRSMSCI 1
PIs Baron, J., J. R. Zucchino, and S. P. Bratton
TITLE Vegetation map: proposed route of Blue Ridge Parkway extension
YEAR 1976-1977 STATUS COMP
INST NPS-UPL
CROSSREF GENVEG,EIS LEVEL LANDSCAPE,COMMUNITY
CITATIONS

PROJREG VEGMAP RMP 26 NOTRMP 2 GRSMSCI
PIs DeSelm, H. R.
TITLE GRSM vegetation and vegetation boundaries, using remote sensing and ERTS-1 imagery
YEAR 1975- STATUS
INST UTennessee
CROSSREF GENVEG,SPRFIR LEVEL LANDSCAPE,COMMUNITY
CITATIONS DeSelm and Taylor 1973

PROJREG VEGMAP RMP 26 NOTRMP 1 GRSMSCI 1
PIs Eagar, C.
TITLE Vegetation map: spruce-fir
YEAR 1981-1983 STATUS COMP
INST NPS-UPL
CROSSREF GENVEG,SPRFIR,AIR-SARR LEVEL LANDSCAPE
CITATIONS

PROJREG VEGMAP RMP 26 NOTRMP 1 GRSMSCI 1
PIs Harmon, M. E.
TITLE Vegetation map: Camels Hump and Huskey Branch
YEAR 1980-1981 STATUS COMP
INST NPS-UPL
CROSSREF GENVEG LEVEL LANDSCAPE
CITATIONS

PROJREG VEGMAP RMF 26 NOTRMP 1 GRSMSCI 1
PIs Howe, T.
TITLE Vegetation map: European wild hog intenstive study area
YEAR 1977- STATUS COMP
INST NPS-UPL
CROSSREF HOGS,GENVEG LEVEL COMMUNITY,LANDSCAPE
CITATIONS Howe et al. 1979

PROJREG VEGMAP RMP 26 NOTRMP 1 GRSMSCI 1
PIs Livingston, D., and C. Mitchell
TITLE Site classification and mapping in the Mt LeConte growth district, GRSM
YEAR 1975-1976 STATUS COMP
INST UMichigan
CROSSREF SPRFIR LEVEL LANDSCAPE,COMMUNITY
CITATIONS Livingston and Mitchell 1976

PROJREG VEGMAP RMP 26 NOTRMP 1 GRSMSCI
PIs Olson, J. S., P. Zinke, and M. E. Harmon
TITLE Remote sensing of ecosystem boundaries and conditions and organic carbon inventory using LANDSAT imagery
YEAR 1977-1980 STATUS COMP
INST ORNL,UC-Berkeley,UTennessee
CROSSREF SPRFIR,GENVEG LEVEL LANDSCAPE,COMMUNITY,ECOSYSTEM
CITATIONS

PROJREG VEGMAP RMP 26 NOTRMP 1 GRSMSCI
PIs Olson, J. S., and P. G. Risser
TITLE Remote sensing and ecosystem properties
YEAR 1984- STATUS ONG
INST PRIV,ORNL,ILL Nat Hist Surv
CROSSREF GENVEG LEVEL LANDSCAPE,ECOSYSTEM
CITATIONS

PROJREG VEGMAP RMP 26 NOTRMP 1 GRSMSCI 1
PIs Shabica, S.
TITLE Remote sensing products applicable to Southeast Region National Parks
YEAR 1977- STATUS COMP
INST NPS-GUIS
CROSSREF GENVEG LEVEL LANDSCAPE
CITATIONS

PROJREG VEGMAP RMF 26 NOTRMP 1 GRSMSCI 1
PIs Su, M. Y.
TITLE Remote sensing for resource basic inventory
YEAR - STATUS
INST NASA
CROSSREF GIS LEVEL LANDSCAPE,COMMUNITY
CITATIONS Su et al. 1975

PROJREG VEGMAP PMF 26.4.C.3 GRSMSCI 1
PIs White, P. S., D. Stratton, and M. D. MacKenzie
TITLE Vegetation map: heath balds and other non-forested areas
YEAR 1981-1982 STATUS COMP
INST NPS-UPL
CROSSREF GRASSYB,GENVEG LEVEL LANDSCAPE
CITATIONS

PROJREG VEGMAP RMP 26.4.C.3 GRSMSCI 1
PIs White, P. S., and J. Rehder
TITLE Vegetation map: remote sensing project
YEAR 1982- STATUS ONG
INST NPS-CPSU,UTennessee
CROSSREF GENVEG LEVEL LANDSCAPE
CITATIONS White and MacKenzie, In press, In press

PROJREG VISIMP RMP 12 NOTRMP 1 GRSMSCI 1
PIs Bratton, S. P., M. G. Hickler, and J. Graves
TITLE Visitor impacts: backcountry trails and campsites
YEAR 1976-1978 STATUS COMP
INST NPS-UPL
CROSSREF LEVEL COMMUNITY,SOILS
CITATIONS Hickler and Bratton 1979; Bratton et al. 1977, 1978, 1980

PROJREG VISIMP RMP 12 NOTRMP 1 GRSMSCI 1
PIs Bratton, S. P., and P. L. Whittaker
TITLE Disturbance and visitation on Mt. LeConte
YEAR 1976-1977 STATUS COMP
INST NPS-UPL
CROSSREF LEVEL COMMUNITY,ENVIRONMENTAL
CITATIONS Bratton and Whittaker 1977; Whittaker and Bratton 1981

PROJREG VISIMP RMP 12 NOTRMP 1 GRSMSCI 1
PIs Nichols, R.
TITLE An assessment of the environmental impact of LeConte Lodge, GRSM
YEAR 1975-1977 STATUS COMP
INST Duke
CROSSREF LEVEL COMMUNITY,ENVIRONMENTAL
CITATIONS Nichols 1977, 1979

PROJREG VISIMP RMP 12 NOTRMP 1 GRSMSCI 1
PIs Renfro, J.
TITLE The incidence and intensity of trail and campsite impacts along the Appalachian Trail
YEAR 1984-1985 STATUS COMP
INST Southern Illinois
CROSSREF LEVEL COMMUNITY,ENVIRONMENTAL
CITATIONS Renfro 1985

PROJREG VISIMP RMP 12 NOTRMP 1 GRSMSCI
PIs Saunders, P. R.
TITLE Human disturbance in southern Appalachian spruce-fir
YEAR 1977-1979 STATUS COMP
INST Duke
CROSSREF SPRFIR,DISTHIST,AIR-SARR,BWA LEVEL COMMUNITY,ENVIRONMENTAL
CITATIONS Saunders 1979, 1984

PROJREG VISIMP RMP 12 NOTRMP 1 GRSMSCI 1
PIs Stromberg, L., and S. P. Bratton
TITLE Permanent plots: backcountry campsite impacts
YEAR 1978-1982 STATUS COMP
INST NPS-UPL
CROSSREF PERMPLOT,FIRE LEVEL COMMUNITY
CITATIONS Bratton and Stromberg 1979; Bratton et al. 1982

PROJREG	VISIMP		RMP	12	NOTRMP 1	GRSMSCI 1	
PIs	Whittaker, P. L., and S. P. Bratton						
TITLE	Comparison of surface impact by hiking and horseback riding						
YEAR	1978-	STATUS COMP					
INST	NPS-UPL						
CROSSREF		LEVEL ENVIRONMENTAL					
CITATIONS	Whittaker and Bratton 1978, 1981						

PROJREG	VISIMP		RMP	12.4.B.1		GRSMSCI 1	
PIs	Wightman, R.						
TITLE	Monitoring of backcountry campsites						
YEAR	1979-	STATUS ONG					
INST	NPS-Rangers						
CROSSREF		LEVEL POPULATION,ENVIRONMENTAL					
CITATIONS							

APPENDIX II

ECOLOGICAL STUDIES IN GREAT SMOKY MOUNTAINS NATIONAL PARK AND BIOSPHERE RESERVE WITH SPECIAL REFERENCE TO VEGETATION, DISTURBANCE, AND MANAGEMENT

AN INDEXED BIBLIOGRAPHY

This bibliography was compiled from the files of the author and from the various published bibliographies available for the southern Appalachians and Great Smoky Mountains National Park (these sources are listed in Part C of this Appendix). Except in a few instances of recently completed work, abstracts are not included. Popular articles have also been excluded except for some early descriptions of natural history survey projects.

For inclusion here, the work in question had to be based on research that was at least partly carried out within GRSM. A few references have been included that are more general works but which publish maps or tables that include the park area. The central theme of this bibliography is, of course, vegetation. Research on floristics, plant populations, communities, environmental relations, and ecoystems have been included. Floristic monographs that treat taxa that occur in the park in the context of a larger geographic area are not included unless they bear on some problem of particular management interest (e.g., dominant trees, susceptibility to threats, and rare plants). A recent bibliography of these works was published in Wofford and White (1982).

For more complete treatments of related subjects see Yurkovich (1984) for geology, Springer and White (1986, in press) for soils, DePriest (1984) for lichen biology, and Evans et al. (1981) and Wofford and White (1982) for vascular plant floristics. Systematics and floristics were reviewed by White (1982). Those bibliographies cover the entire southern Appalachian region and are part of a continuing series of works to be published by the National Park Service in recognition of the larger regional focus of the Man and the Biosphere Program.

This Appendix is divided into four parts:

A. Vegetation bibliography
B. Studies done outside GRSM by the staff of Uplands Field Research Labortory
C. Regional bibliographies
D. Index to key studies

A. VEGETATION BIBLIOGRAPHY FOR GREAT SMOKY MOUNTAINS NATIONAL PARK

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D. INDEX TO KEY STUDIES IN THE BIBLIOGRAPHY

1. Vegetation and ecosystem process studies

Citation	Notes
Ambrosia 1981	Remote sensing and vegetation mapping
Arends 1981	Chestnut blight recovery
Baranski 1975	Ecology of white oak
Barden 1974	Fire and pine
Barden 1979, 1980, 1981, 1983	Gap phase regeneration; hemlock-hardwoods
Barden and Woods 1974, 1976	Fire and pine
Becking and Olson 1978	Permanent plots; spruce-fir
Billings and Mark 1957	Grassy balds
Boner 1979	Balsam woolly aphid; spruce-fir
Bratton 1974, 1975	Wild hog impacts; beech forest
Bratton et al. 1982	Wild hog impacts
Braun 1950	Forest composition and structure
Bruhn 1964	Grassy balds
Busing 1985	Spruce-fir; modelling
Cain 1930a	Floristics
Cain 1930b	Heath balds
Cain 1930c	Vegetation distribution
Cain 1931	Plant distribution and soil pH
Cain 1935	Spruce-fir
Cain 1943	Cove hardwoods
Cain 1945	Life forms
Calloway 1983	Vegetation distribution
Camp 1931	Grassy balds
Cooley 1954	Vegetation distribution
Crandall 1958	Spruce-fir; herbaceous communities
Davidson 1983	Paleoeclogy
Delcourt and Delcourt 1984	Paleoecology
DeLapp and Wentworth 1977	Proposed research natural area; pine forest
DeSelm and Taylor 1973	Spruce-fir; remote sensing
DeYoung 1979	White pine-hardwood
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Fuller 1977	Beech gaps
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Gersmehl 1971	Grassy balds
Gilbert 1954	Grassy balds
Golden 1974, 1981	Vegetation distribution
Harmon 1980, 1980, 1981, 1982	Forest composition; fire history
Harmon 1982	Decomposition
Harmon et al. 1983	Forest composition; disturbance
Huff 1977	Wild hog impacts; beech forest
Johnson 1977	Balsam woolly aphid; spruce-fir
Kuykendall 1978	Southern pine beetle; pine forests
Lacki 1984, 1985	Beech growth
Lindsay and Bratton 1979, 1979, 1980	Grassy balds
Livingston and Mitchell 1976	Vegetation map
McCracken 1978	Logging effects

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Miller 1938	Vegetation map
Oh 1964	Beech forest
Oosting and Billings 1951	Spruce-fir
Pavlovic 1981	Beech gaps
Pittillo 1984	Spruce-fir
Pittillo and Smathers 1979, 1981	Vegetation structure, floristics
Pyle 1985	Human disturbance
Pyle and Schafale 1985	Disturbance in spruce-fir
Radford 1968	Grassy balds
Rheinhardt 1984, 1984	Spruce-fir
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Russell 1953	Beech forest
Saunders 1979	Recreational impacts; spruce-fir
Schofield 1960	Spruce-fir
Shanks 1954	Spruce-fir
Shanks et al. 1961, Shanks and Clebsch 1962	Biomass and nutrient pool estimation
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Walker 1978	Cove hardwoods
Weinstein 1982	Forest dynamics; modelling
Weinstein et al. 1982	Forest dynamics; modelling
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White et al. 1985, in press	Spruce-fir; gap phase regeneration
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Whittaker 1956	Vegetation distribution
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Wingfield 1968	Pine-heath
Wolfe 1967	Spruce-fir
Wolfe and Pittillo 1977	River birch distribution
Woods and Shanks 1959	Chestnut blight recovery
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2. Other general topics

<u>Floristics and plant geography</u>:

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